# Big 6

## Hydrology, Soils, and Fisheries Report

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# Introduction and Overview of Issues

The USDA Forest Service proposes to continue to authorize livestock grazing in the Beaver Creek, Goose Creek, Little Horn River, Rock Creek, and Tensleep Creek areas of the Bighorn National Forest in a manner that moves resource conditions toward meeting forest plan objectives and desired on-the-ground conditions. This report addresses effects of a no action alternative and two action alternatives to hydrology, soil, and fisheries resources within the Big 6 Allotment Management Plan (AMP) Revision project area, hereafter referred to as Big 6. This report describes the affected environment and the environmental consequences of the alternatives relative to issues that have been developed through Interdisciplinary Team (IDT) meetings and scoping. The issues that pertain to this specialist report include:

- Issue 3 – riparian vegetation (includes riparian soils)
- Issue 6 – wildlife, fish, and plant TES and MIS species and species of local concern
- Issue 7 – water quality

The above issues are tracked throughout this report in the heading titles and are analyzed by each alternative in the Environmental Consequences section below. This includes a discussion of analysis indicators used to measure effects to each issue. In this report, the indicator for Issue 3 is acres of sensitive soil type by project area allotments, which determines the area sensitive to soil disturbance and compaction. The analysis indicator for Issue 6 is miles of perennial stream and acres of lake where TES/MIS fish species are present. A thorough determination of effects is also disclosed in the Fisheries Biological Evaluation found in the project record. The indicator for Issue 7 is meeting or moving toward desired condition for water quality, using riparian vegetative conditions as a surrogate. Such riparian vegetative conditions are discussed thoroughly in the rangeland specialist report, while this report discusses known potential effects to water quality.

Additional issues were identified through IDT meetings and scoping but are not analyzed or discussed in this report because they are not relevant to hydrology, fisheries, or soil resources, and they are discussed in another specialist report. These remaining issues include: vacant allotments, aspen stands, upland vegetation, socio/economic, and invasive and noxious weeds.

# Regulatory Framework

The Revised Bighorn National Forest Land and Resource Management Plan (2005) provides a regulatory framework to guide management and protection of the resources analyzed in this report. Direction is found within objectives, strategies, standards and guidelines, and the following are directly applicable to resources analyzed in this report.

Objective 1.a provides a general description of desired conditions for a watershed. It states "Improve and protect watershed conditions to provide the water quality and quantity and soil productivity necessary to support ecological functions and intended beneficial water uses." Applicable strategies under Objective 1.a include: 1 (water quality), 2 (improvement projects), 4 (forest wide aquatic habitat conditions), 5 (6$^{th}$-level watershed aquatic habitat conditions), 6 (native plants), and 7 (wetland function).

Objective 1.b addresses species viability. It states "Provide ecological conditions and habitat within the ecological capability and disturbance regimes of the Forest to sustain well-distributed viable populations of native and desired non-native emphasis species listed in Appendix C of the Revised Plan." Applicable strategies under Objective 1.b include: 1 (conservation strategies) and

11 (natives). The following table summarizes standards and guidelines by forest-wide resource and management area.

**Table 1. Standards and Guidelines applicable to resources analyzed in this report**

| Resource Area / Management Area | Applicable Standard | Applicable Guideline(s) |
|---|---|---|
| Soil, Water, Riparian, and Wetland | 1. In the water influence zone (WIZ), allow only those actions that maintain or improve long-term stream health and riparian ecosystem condition. The WIZ is the aquatic ecosystem, the riparian ecosystem, characterized by distinct vegetation and associated valley bottom (Winters et al. 2003), wetlands, and ecosystems that remain within approximately 100 feet horizontally from both edges of all perennial and intermittent streams and from the shores of lakes and other still water bodies. It includes adjacent, unstable and highly erodible soil. | 1. Incorporate appropriate practices and design criteria from the Watershed Conservation Practices Handbook into all project design, analysis, and decision documents. |
| Fisheries | NA | 1. Maintain, continue, and use baseline data and inventories of forest streams and watersheds as references to evaluate the condition of aquatic habitats and identify fisheries enhancement opportunities.<br>2. Use watershed function and channel geomorphology principles when planning for the protection, restoration, or enhancement of aquatic habitats.<br>3. Mitigate or avoid impacts to aquatic species through the application of state BMPs and Water Conservation Practices Handbook (WCPH) direction to protect, maintain, or restore habitat conditions to provide for persistence and production of fish and aquatic habitats. |

Soil and water practices and design criteria, for Region 2, are contained in Chapter 10 of the Handbook, FSH 2509.25

The following are additional regulatory orders and acts, which are applicable to the resources analyzed in this report:

**Fish and Wildlife Act of 1956** (16 U.S.C. 742a-d, and e-j)

**Fish and Wildlife Coordination Act** (16 U.S.C. 661-666c)

**National Environmental Policy Act of 1969**

**Executive Order 12962 – Recreational Fisheries, of 1995**. This EO orders Federal agencies, to the extent permitted by law and where practicable, and in cooperation with States and Tribes, improve the quantity, function, sustainable productivity and distribution of U.S. aquatic resources for increased recreational fishing opportunities.

**Clean Water Act of 1972**. The Act was amended in 1977 and 1987 (Public Law 100-4) to protect and improve the quality of water resources and maintain their beneficial uses. Section 313 of the Clean Water Act and EO 12088 of January 23, 1987 address Federal agency compliance and consistency with water pollution control mandates. Agencies must be consistent with requirements that apply to "any governmental entity" or person. Compliance is to be in line with "all Federal, State, interstate and local requirements, administrative authority and processes and sanctions respecting the control and abatement of water pollution."

The Clean Water Act (Sections 208 and 319) recognized the need for control strategies for nonpoint source pollution. Soil and water conservation practices (BMP's) were recognized as the primary control mechanisms for nonpoint source pollution on National Forest System Lands. The Environmental Protection Agency supports this perspective.

The Forest Service and the Bighorn National Forest must apply Best Management Practices that are consistent with the Wyoming Department of Environmental Quality and Environmental Protection Agency to achieve Wyoming Water Quality Standards. The site-specific application of BMP's, with a monitoring and feedback mechanism, is the approved strategy for controlling nonpoint source pollution.

**Executive Order 11990 – Protection of Wetlands**. This 1977 executive order requires the Forest Service to take action to minimize destruction, loss or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands.

**Executive Order 11988 – Floodplain Management**. This 1977 executive order requires the Forest Service to take action to:

- Minimize adverse impacts associated with the occupancy and modification of flood plains and reduce risks of flood loss.
- Minimize impacts of floods on human safety, health, and welfare.
- Restore and preserve the natural and beneficial values of wetlands.

Other pertinent statues that conserve, restore, and enhance hydrologic, soil, and fisheries resources, may also be applicable.

# Affected Environment

Several methods and sources of information were applied during the development of existing and desired conditions and the analysis of alternatives. Bighorn National Forest (BNF) GIS data were used to generate portions of the data reported in tables and text. Numerous site visits and Interdisciplinary Team (IDT) field trips occurred within the analysis and project areas. Observations made during these trips added to the writer's knowledge of the area. Refereed literature and several books were used to provide examples of documented effects of livestock grazing on the resource areas. These sources of information were used to describe existing conditions, develop and support desired future conditions, and were used as a basis for effects analysis.

Belsky et al. (1999) reviewed over 140 peer-reviewed papers that reviewed the biological and physical effects of livestock grazing on water quality, channel morphology, stream flow pattern, soils, vegetation, and aquatic and riparian wildlife. The authors found no peer-reviewed literature that reported a positive effect of livestock grazing on soil and aquatic resources, when compared to ungrazed controls. Several studies reported no significant difference between grazed and ungrazed conditions, and attributed these findings to random variables or study design problems. One limitation to the Belsky et al. (1999) document is that it does not present original research; instead, it summarizes data, studies, and findings of over 140 studies related to livestock grazing in uplands, riparian areas, and stream channels.

Kauffman and Krueger (1984) reviewed over 100 sources of information with the purpose of disclosing facts and theories regarding livestock grazing and riparian areas and found similar results to Belsky et al. (1999). This review has the same limitations as Belsky et al. (1999).

Although the two review papers have known limitations, they are valuable tools. The reviews summarize large amounts of research into an understandable format. The summarized information is presented in an unbiased way and the authors of these two papers state what other researchers have found.

## *Existing Condition*

### Project Area and Analysis Area Description

Hydrology, soil, and fisheries resources analyzed in this document are evaluated in two different spatial scales: the project area and the analysis area. The project area is the land within the 43 allotments that make up the Big 6 Allotment Management Plan decision. The Environmental Impact Statement (EIS) contains a full description of the project area boundary.

Amy Ortner pointed out that the correct Big 6 allotment acres is 392,243 acres. The 401,738 acres includes land that is not within allotment boundaries. Changes are made in the below paragraph and throughout this report.

The analysis area for hydrology, soil, and fishery resources is defined as all 6$^{th}$-level watersheds that intersect the project area allotments within the Bighorn National Forest boundary. Watersheds containing only a small amount of the project area (less than 10%) were removed from further consideration; see the following table. It is assumed that the effects of management activities on resources are not measurable at this small of a scale. However, the three watersheds that intersect the Paintrock area (Matthew's Ridge and South Park allotments) were included in the analysis although they cover less than 10% of the project area. This allows these two small allotments to be incorporated in the analysis. Altogether, 53 watersheds intersect the project area allotments and 31 watersheds are analyzed throughout this report. In this report, the analysis area encompasses approximately 570,277 watershed acres, of which the project area is over ~~401,738~~ 392,243 allotment acres, or approximately 70% of the analysis area.

A map showing the location of the project area and analysis area are illustrated in the figures below.

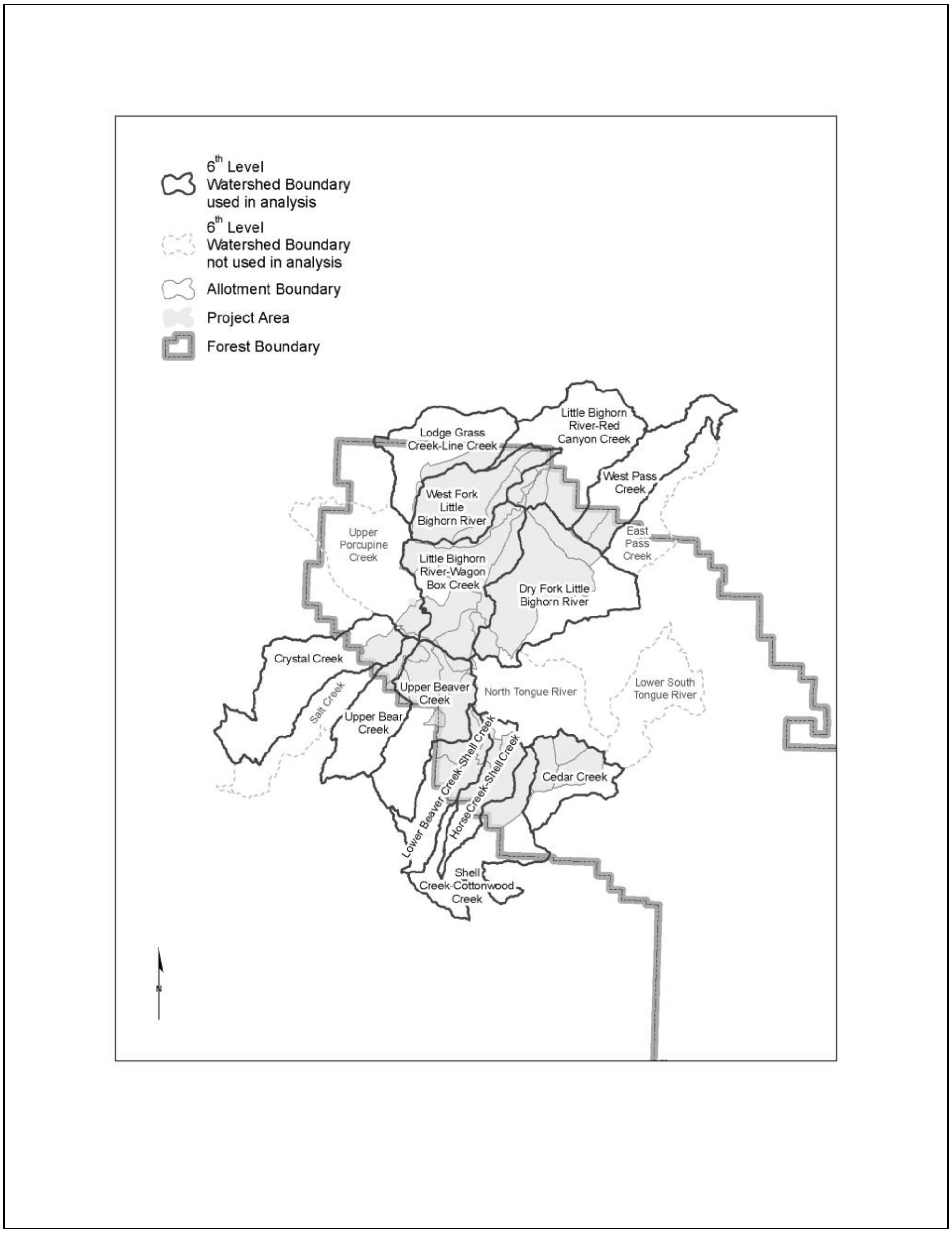


**Figure 1. Map of project area (allotments) and analysis area (watersheds) in the north part of the forest. Analysis area is only evaluated for the area that falls within the BNF boundary and for the watersheds that intersect more than 10% of the project area.**

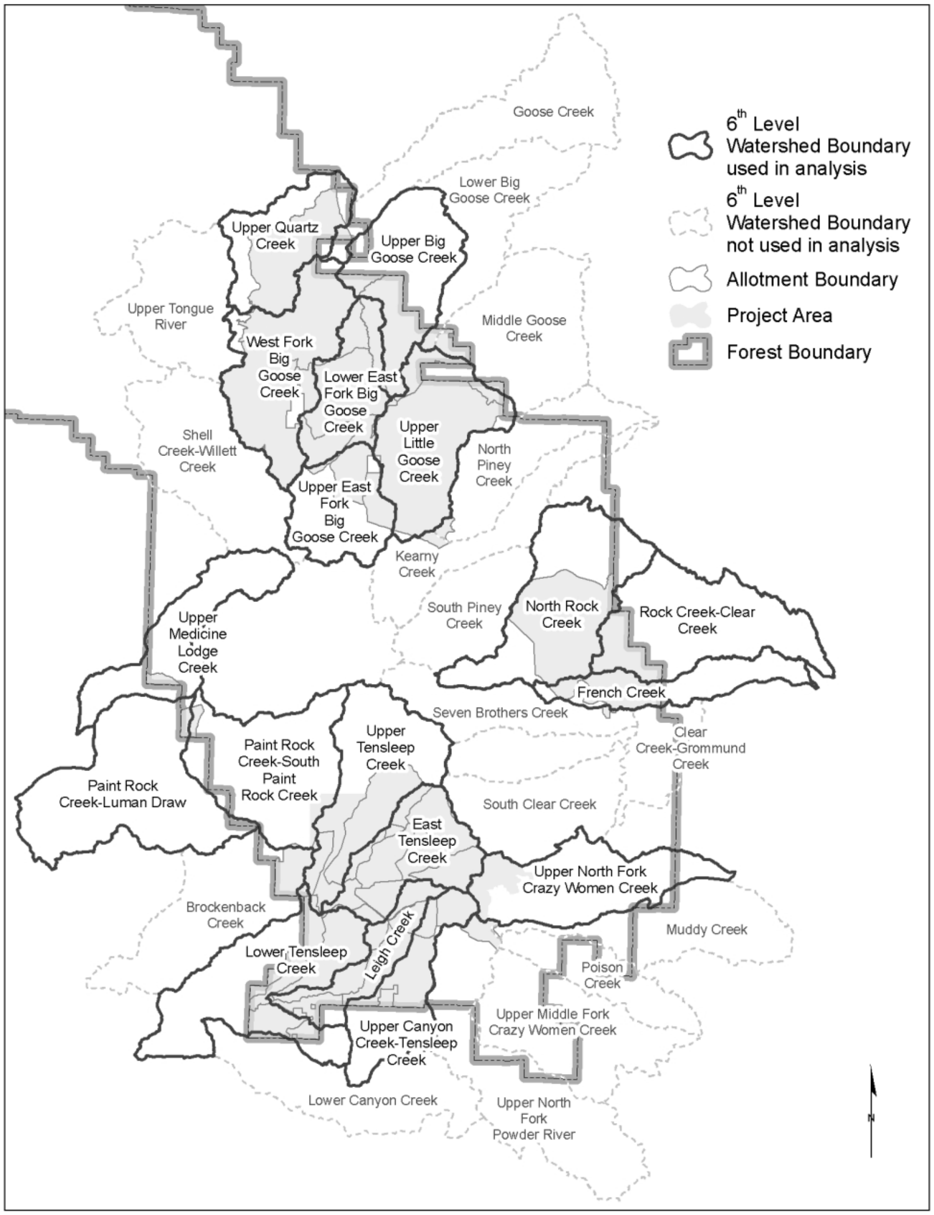


**Figure 2. Map of project area (allotments) and analysis area (watersheds) in the south part of the forest. Analysis area is only evaluated for the area that falls within the BNF boundary and for the watersheds that intersect more than 10% of the project area.**

**Table 2. Watersheds defining the analysis area; grey/italicized watersheds were removed from further consideration because they cover less than 10% of the project area; black/italicized watersheds were analyzed further because they incorporate the two small Paintrock area allotments.**

| 6th-level watershed | Total watershed acres | Watershed acres managed by BNF | Percent of watershed managed by BNF | Watershed acres in Big 6 allotments | Percent of watershed in Big 6 allotments |
|---|---|---|---|---|---|
| **Beaver Creek Project Area** | | | | | |
| Little Bighorn River-Wagon Box Creek | 35,070 | 35,070 | 100% | 31,286 | 89% |
| Dry Fork Little Bighorn River | 46,301 | 46,301 | 100% | 31,830 | 69% |
| Horse Creek-Shell Creek | 15,561 | 10,981 | 71% | 9,615 | 62% |
| Cedar Creek | 18,343 | 18,343 | 100% | 11,164 | 61% |
| Upper Beaver Creek | 32,937 | 17,382 | 53% | 17,715 | 54% |
| Lower Beaver Creek-Shell Creek | 20,477 | 9,796 | 48% | 9,796 | 48% |
| Shell Creek-Cottonwood Creek | 28,118 | 10,740 | 38% | 6,155 | 22% |
| Upper Bear Creek | 20,507 | 2,823 | 14% | 2,823 | 14% |
| Crystal Creek | 37,024 | 7,274 | 20% | 3,706 | 10% |
| *Upper Porcupine Creek* | *35,143* | *31,327* | *89%* | *3,008* | *9%* |
| *Paint Rock Creek-South Paint Rock Creek* | *36,428* | *33,515* | *92%* | *2,053* | *6%* |
| *Upper Medicine Lodge Creek* | *24,306* | *17,762* | *73%* | *605* | *3%* |
| *North Tongue River* | *28,720* | *28,720* | *100%* | *442* | *2%* |
| *Salt Creek* | *17,522* | *240* | *1%* | *240* | *1%* |
| *Paint Rock Creek-Luman Draw* | *47,343* | *1,267* | *3%* | *574* | *1%* |
| *Lower South Tongue River* | *23,492* | *23,054* | *98%* | *12* | *0.10%* |
| **Goose Creek Project Area** | | | | | |
| Lower East Fork Big Goose Creek | 19,600 | 19,428 | 99% | 19,428 | 99% |
| Upper Little Goose Creek | 32,330 | 29,810 | 92% | 28,935 | 90% |
| West Fork Big Goose Creek | 33,994 | 32,057 | 94% | 30,742 | 90% |
| Upper Quartz Creek | 23,692 | 22,657 | 96% | 12,599 | 53% |
| Upper East Fork Big Goose Creek | 20,601 | 20,192 | 98% | 6,624 | 32% |
| Upper Big Goose Creek | 28,856 | 9,477 | 33% | 8,681 | 30% |
| *Middle Goose Creek* | *35,754* | *1,614* | *5%* | *1,573* | *4%* |
| *Kearny Creek* | *24,942* | *23,758* | *95%* | *554* | *2%* |
| *Lower Big Goose Creek* | *27,141* | *658* | *2%* | *658* | *2%* |
| *North Piney Creek* | *25,199* | *18,949* | *75%* | *580* | *2%* |
| *Goose Creek* | *39,075* | *1,002* | *3%* | *396* | *1%* |
| *Shell Creek-Willett Creek* | *37,697* | *37,627* | *100%* | *29* | *0.10%* |
| *Upper Tongue River* | *31,052* | *31,052* | *100%* | *16* | *0.10%* |
| **Little Horn Project Area** | | | | | |
| West Fork Little Bighorn River | 24,307 | 23,935 | 99% | 23,846 | 98% |
| Little Bighorn River-Wagon Box Creek | 35,070 | 35,070 | 100% | 31,286 | 89% |
| Dry Fork Little Bighorn River | 46,301 | 46,301 | 100.00% | 31,830 | 69% |
| Little Bighorn River-Red Canyon Creek | 39,007 | 10,212 | 26% | 10,212 | 26% |
| West Pass Creek | 26,855 | 4,859 | 18% | 4,795 | 18% |
| Lodge Grass Creek-Line Creek | 27,300 | 13,947 | 51% | 4,376 | 16% |
| *Upper Porcupine Creek* | *35,143* | *31,327* | *89%* | *3,008* | *9%* |
| *East Pass Creek* | *17,297* | *7,306* | *42%* | *14* | *0.10%* |
| **Rock Creek Project Area** | | | | | |
| North Rock Creek | 40,048 | 36,095 | 90% | 17,086 | 43% |
| French Creek | 16,906 | 7,348 | 44% | 6,025 | 36% |
| Rock Creek-Clear Creek | 37,837 | 5,407 | 14% | 5,407 | 14% |
| *Seven Brothers Creek* | *20,998* | *20,848* | *99%* | *234* | *1%* |
| *Clear Creek-Grommund Creek* | *12,920* | *10,028* | *78%* | *42* | *0.30%* |
| *South Piney Creek* | *21,716* | *21,716* | *100%* | *5* | *0.02%* |

| 6th-level watershed | Total watershed acres | Watershed acres managed by BNF | Percent of watershed managed by BNF | Watershed acres in Big 6 allotments | Percent of watershed in Big 6 allotments |
|---|---|---|---|---|---|
| **Tensleep Project Area** | | | | | |
| East Tensleep Creek | 23,623 | 23,623 | 100% | 21,291 | 90% |
| Leigh Creek | 14,959 | 13,545 | 90% | 13,415 | 90% |
| Upper Canyon Creek-Tensleep Creek | 21,164 | 10,055 | 48% | 9,768 | 46% |
| Lower Tensleep Creek | 40,771 | 15,837 | 39% | 13,666 | 34% |
| Upper Tensleep Creek | 33,070 | 33,070 | 100% | 11,123 | 34% |
| Upper North Fork Crazy Women Creek | 29,999 | 27,469 | 92% | 4,026 | 13% |
| *Brockenback Creek* | *35,373* | *3,821* | *11%* | *3,025* | *9%* |
| *Paint Rock Creek-South Paint Rock Creek* | *36,428* | *33,515* | *92%* | *2,053* | *6%* |
| *Upper North Fork Powder River* | *44,904* | *12,549* | *28%* | *1,585* | *4%* |
| *Lower Canyon Creek* | *33,532* | *356* | *1%* | *356* | *1%* |
| *Muddy Creek* | *28,000* | *5,504* | *20%* | *65* | *0.20%* |
| *South Clear Creek* | *27,028* | *27,028* | *100%* | *37* | *0.10%* |
| *Poison Creek* | *16,707* | *5,708* | *34%* | *5* | *0.03%* |
| *Upper Middle Fork Crazy Women Creek* | *35,184* | *16,746* | *48%* | *4* | *0.01%* |
| **TOTAL:** | **1,516,730** | **899,888** | **-** | **392,243** | - |

- Acreage discrepancies are due to GIS calculations and rounding errors. Note that four 6th-level watersheds intersect multiple project areas, and therefore are repeated in the table above.

## Hydrology

### *Streams*

There are approximately 2,227 miles of stream within the analysis area watersheds, of which 651 miles (29%) are perennial, 993 miles (45%) are intermittent, and 583 miles (26%) are ephemeral. Approximately 1,510 miles of stream lie within the project area, of which 436 (29%) are perennial, 683 (45%) are intermittent, and 390 (26%) are ephemeral. The Dry Fork Little Bighorn River watershed contains the most miles of stream within the analysis area (201 miles), and the Walker Prairie allotment contains the most stream miles within the project area (142 miles). Stream data was derived from the NHDFlowline GIS layer.

**Table 3. Miles of perennial, intermittent, and ephemeral streams in the analysis area (on forest)**

| 6th-level watershed | Stream length (miles) | | | Total miles |
|---|---|---|---|---|
| | Perennial | Intermittent | Ephemeral | |
| **Beaver Creek Project Area** | | | | |
| Dry Fork Little Bighorn River | 55 | 99 | 47 | **201** |
| Paint Rock Creek-South Paint Rock Creek | 45 | 56 | 39 | **139** |
| Little Bighorn River-Wagon Box Creek | 34 | 63 | 20 | **117** |
| Upper Beaver Creek | 13 | 51 | 25 | **89** |
| Upper Medicine Lodge Creek | 19 | 32 | 22 | **72** |
| Cedar Creek | 22 | 26 | 17 | **64** |
| Shell Creek-Cottonwood Creek | 12 | 25 | 25 | **62** |
| Horse Creek-Shell Creek | 23 | 10 | 15 | **47** |
| Lower Beaver Creek-Shell Creek | | 32 | 10 | **42** |
| Crystal Creek | 8 | 17 | 11 | **36** |
| Upper Bear Creek | | 10 | 4 | **14** |
| Paint Rock Creek-Luman Draw | | 1 | 2 | **3** |

| 6th-level watershed | Stream length (miles) | | | Total miles |
|---|---|---|---|---|
| | Perennial | Intermittent | Ephemeral | |
| **Goose Creek Project Area** | | | | |
| West Fork Big Goose Creek | 49 | 27 | 38 | **114** |
| Upper Little Goose Creek | 37 | 38 | 36 | **111** |
| Upper Quartz Creek | 34 | 25 | 32 | **91** |
| Lower East Fork Big Goose Creek | 22 | 31 | 22 | **76** |
| Upper East Fork Big Goose Creek | 22 | 18 | 12 | **52** |
| Upper Big Goose Creek | 11 | 27 | 14 | **51** |
| **Little Horn Project Area** | | | | |
| Dry Fork Little Bighorn River | 55 | 99 | 47 | **201** |
| Little Bighorn River-Wagon Box Creek | 34 | 63 | 20 | **117** |
| West Fork Little Bighorn River | 27 | 49 | 24 | **100** |
| Lodge Grass Creek-Line Creek | 11 | 27 | 11 | **50** |
| Little Bighorn River-Red Canyon Creek | 14 | 20 | 11 | **45** |
| West Pass Creek | 5 | 10 | 3 | **18** |
| **Rock Creek Project Area** | | | | |
| North Rock Creek | 40 | 58 | 32 | **130** |
| French Creek | 8 | 14 | 9 | **32** |
| Rock Creek-Clear Creek | 8 | 8 | 8 | **24** |
| **Tensleep Project Area** | | | | |
| Upper Tensleep Creek | 33 | 56 | 34 | **123** |
| Upper North Fork Crazy Women Creek | 32 | 32 | 30 | **93** |
| Lower Tensleep Creek | 17 | 44 | 12 | **74** |
| East Tensleep Creek | 26 | 34 | 8 | **67** |
| Leigh Creek | 13 | 30 | 7 | **50** |
| Upper Canyon Creek-Tensleep Creek | 10 | 26 | 4 | **39** |
| **TOTAL:** | **651** | **993** | **583** | ***2,227*** |

- Mileage discrepancies are due to GIS calculations and rounding errors. Note that two 6th-level watersheds intersect multiple project areas, and therefore are repeated in the table above.

**Table 4. Miles of perennial, intermittent, and ephemeral streams in the project area**

| Allotment | Stream length (miles) | | | Total miles |
|---|---|---|---|---|
| | Perennial | Intermittent | Ephemeral | |
| **Beaver Creek Project Area** | | | | |
| Sunlight Mesa C&H | 23 | 18 | 17 | **58** |
| Bear/Crystal Creek S&G | 5 | 24 | 8 | **38** |
| Hunt Mountain S&G | 1 | 25 | 12 | **38** |
| Whaley Creek S&G | 8 | 18 | 10 | **36** |
| Red Canyon C&H | 2 | 21 | 9 | **32** |
| Beaver Creek S&G | 3 | 13 | 7 | **23** |
| Grouse Creek S&G | 7 | 6 | 4 | **18** |
| Little Horn S&G | 3 | 12 | 3 | **18** |
| Wiley Sundown C&H | 5 | 5 | 4 | **14** |
| Finger Creek C&H | 3 | 4 | 2 | **9** |
| Red Canyon S&G | 4 | 3 | 2 | **9** |
| Antelope Ridge S&G | 3 | 4 | 2 | **8** |
| South Park C&H | | 2 | 1 | **2** |
| Matthew's Ridge C&H | | 1 | 0 | **1** |
| **Goose Creek Project Area** | | | | |
| Walker Prairie C&H | 47 | 44 | 50 | **142** |
| Little Goose C&H | 35 | 35 | 28 | **97** |
| Rapid Creek C&H | 17 | 35 | 28 | **80** |
| Stull Lakes C&H | 23 | 10 | 17 | **50** |
| Big Goose C&H | 15 | 14 | 9 | **38** |

| Allotment | Stream length (miles) | | | Total miles |
|---|---|---|---|---|
| | Perennial | Intermittent | Ephemeral | |
| Tourist Horse GRA | 7 | 1 | 1 | **10** |
| Little Goose Canyon C&H | 3 | 1 | 1 | **5** |
| **Little Horn Project Area** | | | | |
| Lake Creek C&H | 37 | 46 | 27 | **110** |
| Red Springs C&H | 28 | 50 | 20 | **99** |
| Little Horn C&H | 24 | 21 | 8 | **52** |
| Lower Dry Fork C&H | 9 | 16 | 14 | **39** |
| Wyoming Gulch C&H | 7 | 18 | 6 | **31** |
| Dry Fork Ridge C&H | 8 | 16 | 5 | **30** |
| Sage Basin C&H | 4 | 12 | 8 | **23** |
| Fisher Mountain C&H | 1 | 5 | 4 | **10** |
| West Pass C&H | 2 | 5 | 2 | **8** |
| **Rock Creek Project Area** | | | | |
| Rock Creek C&H | 37 | 50 | 34 | **121** |
| **Tensleep Project Area** | | | | |
| South Canyon C&H | 15 | 34 | 7 | **55** |
| North Canyon C&H | 10 | 23 | 5 | **39** |
| Willow S&G | 11 | 12 | 7 | **29** |
| Dry Tensleep C&H | | 13 | 7 | **20** |
| McLain Lake S&G | 5 | 12 | 3 | **19** |
| Upper Meadows S&G | 9 | 5 | 1 | **15** |
| Garnet Creek S&G | 1 | 8 | 5 | **14** |
| Hazelton S&G | 2 | 7 | 3 | **12** |
| Tensleep Canyon C&H | 2 | 7 | 3 | **12** |
| Leigh Creek S&G | 2 | 8 | 1 | **11** |
| Monument C&H | 2 | 8 | 1 | **11** |
| Baby Wagon S&G | 5 | 3 | 0 | **9** |
| Battlepark C&H | 0 | 3 | 2 | **5** |
| Crazy Woman S&G | 1 | 2 | 2 | **5** |
| **TOTAL:** | **436** | **683** | **390** | ***1,510*** |

- Mileage discrepancies are due to GIS calculations and rounding errors.

### *Water Quality (Issue 7)*

Beneficial uses specific to waters within the project area include: agriculture, fisheries, drinking water, recreation, scenic value, aquatic life other than fish, wildlife, and fish consumption (WYDEQ 2007). Currently, there are no streams in the analysis area listed in Wyoming's 2008 305(b) State Water Quality Assessment Report and 2008 303(d) list of waters with Water Quality Impairments. While Big Goose Creek, Little Goose Creek, Rapid Creek, Jackson Creek, and Wolf Creek are on the 303(d) list, these sections of stream are located downstream of the analysis area boundary, off forest. The water quality in the project area meets the designated uses for the majority of the year, except for possible seasonal fluctuations in bacterial concentrations in some stream reaches during times of livestock grazing.

The 2001 DEQ Wyoming Surface Water Classification List identifies Class 2AB and Class 3B waters in the project area. Class 2AB waters sustain game fish populations and serve as drinking water supplies. A few examples of Class 2AB waters include: Babione Creek, Little Bighorn River, Tensleep Creek, and Quartz Creek. Class 3B waters are intermittent and ephemeral streams that are not known to sustain fish populations or support drinking water supplies. Some examples of 3B waters include: Balm of Gilead Creek, Bone Creek, Finger Creek, and Ice Creek.

### BMP Reviews

Best Management Practice (BMP) reviews are conducted on randomly selected livestock grazing allotments each year to meet the requirements of the Clean Water Act and the direction outlined in the Revised Forest Plan (2005). The reviews follow Watershed Conservation Practices Handbook (WCPH) management measures and design criteria (USFS 2006). BMP reviews have been conducted on three allotments within the Big 6 project area: Wiley Sundown pasture/Wiley Sundown allotment, Lower Unit pasture/Walker Prairie allotment, and Trap pasture/Monument allotment. BMP field reviews identify if WCPH criteria are followed, if grazing guidelines are implemented, and provide an opportunity to recognize future opportunities for soil and watershed improvements in an interdisciplinary team setting.

The Wiley Sundown pasture of the Wiley Sundown allotment is located within the Beaver Creek Project Area, and was reviewed on September 2, 2009. This BMP review identified opportunities to improve existing spring developments and to close a road before it crosses a stream (after which the road ends). In general, organic ground cover was not adequate in portions of the pasture to prevent increased surface erosion. Therefore, the BMP review identified the need to monitor annual production/utilization in this area.

On September 24, 2009, a BMP review was conducted in the Lower Unit pasture of the Walker Prairie allotment. This review falls within the Goose Creek Project Area and identified the need to explore water development opportunities. There are no water developments in this pasture, and therefore, riparian areas are slightly over-utilized. However, the logistics of transporting materials to the Lower Unit pasture are extremely difficult and may not be economically feasible. A riparian photo point was established in the 2009 review, to identify changes in riparian condition during future BMP reviews or other range reviews, but not part of the permanent range photo points. Overall, the watershed condition is good in this pasture, as the riparian overgrazing at watering locations is minimal, and the uplands have good vegetative cover.

The Trap pasture of the Monument allotment was reviewed on October 9, 2008 and lies within the Tensleep Project Area. This review identified action items to halt the spread of thistle, to prevent gates being left open by recreationists, and confirmed the successful implementation of the current rotation strategy and grazing guidelines. There was excellent ground cover throughout the pasture, concentrated use sites are located outside of the Water Influence Zone (WIZ), and the few WIZs within the pasture meet applicable standards and guidelines.

Overall, the application of BMPs, in conjunction with the implementation of Bighorn National Forest Vegetation Grazing Guidelines (2007) by each District, provides adequate protection for designated uses and enables interdisciplinary teams to identify opportunities for soil and watershed improvements.

### Wilderness Watch

The Cloud Peak Chapter of Wilderness Watch sampled water quality within or near the Cloud Peak Wilderness of the Bighorn National Forest between 2000 and 2007 (Wilderness Watch 2009). Sample collection and analysis follows Wyoming Department of Environmental Quality methods. A total of 22 streams were sampled, 9 of which fall within the Big 6 project area, and all streams had excellent water quality. The streams within the project area include: East Fork Big Goose Creek, East Fork Little Goose Creek, Coney Creek, Cross Creek, South Rock Creek*, East Tensleep Creek*, Middle Tensleep Creek, West Tensleep Creek, Wilderness Creek*. (Streams with asterisks were sampled outside of the Cloud Peak Wilderness area.

### *Water Quantity*

The geographical location of the Big Horn Mountains has a direct effect on precipitation patterns, and therefore on surface runoff and stream discharge. Given that the Big Horn Mountains are on the eastern margin of the Rocky Mountain complex, westerly winds are driven down slope and typically lack moisture. The eastern portion of the Big Horn Mountains receives moisture from winds out of the prairie region to the east. Major storm tracks come from the north, producing northeast winds which yield higher precipitation on the northeast section of the range and intensify a rain shadow southeast of Cloud Peak, the highest peak in the Bighorns at an elevation of 13,175 feet.

The climate of the area is influenced by frontal systems and orographic storms during winter months and by orographic and convectional storms during the summer months. Approximately 70% of yearly precipitation falls in the form of snow, and more than 95% of all surface runoff is directly, or indirectly, the result of snowmelt. In response to local thunderstorms, summer storm flows represent a small amount of the total rainfall event precipitation.

## Lakes, Wetlands, and Riparian (Issue 3)

The project area contains approximately 1,052 lake acres, 2,037 wetland acres, and 49,794 riparian acres. Tourist Horse GRA has the most acres of lakes (381 acres), Stull Lakes C&H contains the largest wetland acres (579 acres), and Walker Prairie C&H has the most riparian area (7,908 acres). Data derived from the NHDWaterbody GIS layer. For riparian acres, this GIS layer includes both forested and rangeland vegetation, and therefore might not correspond to riparian acres identified in the rangeland specialist report.

**Table 5. Acres of lakes, wetlands, and riparian areas within the project area**

| Allotments | Lake acres | Wetland acres | Riparian acres |
|---|---|---|---|
| **Beaver Creek Project Area** | | | |
| Whaley Creek S&G | | | 2,270 |
| Little Horn S&G | 0.2 | | 1,152 |
| Hunt Mountain S&G | 1 | | 831 |
| Bear/Crystal Creek S&G | 2 | | 821 |
| Sunlight Mesa C&H | 2 | | 745 |
| Beaver Creek S&G | 0.1 | | 691 |
| Red Canyon C&H | 0.3 | | 266 |
| Grouse Creek S&G | 0.1 | | 256 |
| Antelope Ridge S&G | 1 | 1 | 244 |
| Wiley Sundown C&H | 0.1 | | 179 |
| Red Canyon S&G | 0.2 | | 141 |
| Finger Creek C&H | | | 91 |
| Matthew's Ridge C&H | | | 14 |
| South Park C&H | | | 0.1 |
| **Goose Creek Project Area** | | | |
| Walker Prairie C&H | 102 | 227 | 7,908 |
| Little Goose C&H | 160 | 130 | 5,588 |
| Big Goose C&H | 82 | 350 | 4,906 |
| Rapid Creek C&H | 0.2 | 126 | 2,968 |
| Stull Lakes C&H | 194 | 597 | 2,809 |
| Tourist Horse GRA | 381 | 122 | 1,622 |
| Little Goose Canyon C&H | | | 113 |
| **Little Horn Project Area** | | | |
| Lake Creek C&H | 3 | 25 | 1,775 |
| Wyoming Gulch C&H | 0.3 | | 1,499 |
| Little Horn C&H | 3 | | 1,147 |

| Allotments | Lake acres | Wetland acres | Riparian acres |
|---|---|---|---|
| Red Springs C&H | 4 | | 1,003 |
| Lower Dry Fork C&H | 0.4 | | 456 |
| Dry Fork Ridge C&H | | | 350 |
| Sage Basin C&H | 1 | | 265 |
| West Pass C&H | | | 105 |
| Fisher Mountain C&H | | | 70 |
| **Rock Creek Project Area** | | | |
| Rock Creek C&H | 10 | 25 | 2,315 |
| **Tensleep Project Area** | | | |
| McLain Lake S&G | 51 | 125 | 1,275 |
| Upper Meadows S&G | 14 | 110 | 999 |
| South Canyon C&H | 1 | 32 | 993 |
| Willow S&G | 33 | 62 | 923 |
| Hazelton S&G | | 24 | 562 |
| North Canyon C&H | 1 | | 522 |
| Baby Wagon S&G | 1 | 21 | 496 |
| Garnet Creek S&G | | | 389 |
| Leigh Creek S&G | | 35 | 322 |
| Dry Tensleep C&H | 4 | 20 | 236 |
| Tensleep Canyon C&H | | 4 | 168 |
| Crazy Woman S&G | | | 141 |
| Monument C&H | | | 114 |
| Battlepark C&H | | | 55 |
| **TOTAL:** | **1,052** | **2,037** | **49,794** |

- Acreage discrepancies are due to GIS calculations and rounding errors.

The analysis area contains approximately 2,541 acres of lakes, 3,020 acres of wetlands, and 68,341 acres of riparian areas. West Fork Big Goose Creek has the largest area of lakes (509 acres) and wetlands (837 acres), and Lower East Fork Big Goose Creek contains the largest riparian area (8,776 acres).

**Table 6. Acres of lakes, wetlands, riparian areas, and riparian and wetland clusters for the watersheds comprising the analysis area (on forest). Italicized watersheds are most sensitive to anthropogenic activities.**

| 6th-level watershed | Lake acres | Wetland acres | Riparian acres | Riparian cluster | Riparian rank | Wetland cluster | Wetland rank |
|---|---|---|---|---|---|---|---|
| **Beaver Creek Project Area** | | | | | | | |
| Upper Beaver Creek | 0.1 | | 4,108 | 6r | 48 | 6w | 46 |
| *Little Bighorn River-Wagon Box Creek* | *4* | | *3,991* | *1r* | *14* | *2w* | *14* |
| *Paint Rock Creek-South Paint Rock Creek* | *42* | *67* | *2,939* | *1r* | *9* | *1w* | *9* |
| Dry Fork Little Bighorn River | 3 | 26 | 2,799 | 5r | 36 | 5w | 36 |
| *Upper Medicine Lodge Creek* | *149* | *128* | *1,982* | *2r* | *54* | *1w* | *54* |
| Cedar Creek | 0.4 | | 940 | 4r | 55 | 5w | 56 |
| Crystal Creek | 2 | | 838 | 6r | 41 | 6w | 41 |
| Horse Creek-Shell Creek | 2 | | 675 | 4r , 5r | 40, 46 | 5w, 6w | 40, 47 |
| Shell Creek-Cottonwood Creek | 1 | | 522 | 5r | 46 | 6w | 47 |
| Lower Beaver Creek-Shell Creek | 1 | | 411 | 5r | 44, 46 | 6w | 43, 47 |
| Upper Bear Creek | | | 286 | 6r | 58 | 6w | 58 |
| Paint Rock Creek-Luman Draw | 0.4 | | 28 | 5r | 62 | 4w | 62 |
| **Goose Creek Project Area** | | | | | | | |
| *Lower East Fork Big Goose* | *455* | *482* | *8,776* | *1r* | *1* | *1w* | *1* |

| 6th-level watershed | Lake acres | Wetland acres | Riparian acres | Riparian cluster | Riparian rank | Wetland cluster | Wetland rank |
|---|---|---|---|---|---|---|---|
| *Creek* | | | | | | | |
| West Fork Big Goose Creek | 509 | 837 | 7,277 | 1r | 34 | 1w | 34 |
| *Upper Little Goose Creek* | *89* | *128* | *6,266* | *3r* | *8* | *3w* | *8* |
| Upper East Fork Big Goose Creek | 401 | 171 | 2,754 | 1r | 35 | 1w | 35 |
| *Upper Quartz Creek* | *0.3* | *105* | *2,219* | *3r* | *24* | *2w* | *23* |
| Upper Big Goose Creek | 0.1 | 40 | 1,841 | 6r | 26 | 6w | 26 |
| **Little Horn Project Area** | | | | | | | |
| *Little Bighorn River-Wagon Box Creek* | *4* | | *3,991* | *1r* | *14* | *2w* | *14* |
| Dry Fork Little Bighorn River | 3 | 26 | 2,799 | 5r | 36 | 5w | 36 |
| West Fork Little Bighorn River | 3 | | 1,044 | 5r | 60 | 5w | 60 |
| Lodge Grass Creek-Line Creek | 2 | | 774 | 5r | 61 | 5w | 61 |
| Little Bighorn River-Red Canyon Creek | 1 | | 629 | 5r | 43 | 6w | 45 |
| West Pass Creek | | | 228 | 5r | 33 | 6w | 33 |
| **Rock Creek Project Area** | | | | | | | |
| North Rock Creek | 18 | 63 | 2,540 | 3r | 50 | 3w | 49 |
| French Creek | 19 | 45 | 785 | 3r | 23 | 3w | 24 |
| Rock Creek-Clear Creek | 1 | | 470 | 3r | 67 | 6w | 67 |
| **Tensleep Project Area** | | | | | | | |
| East Tensleep Creek | 445 | 314 | 3,984 | 1r | 15 | 1w | 13 |
| Upper Tensleep Creek | 376 | 279 | 3,683 | 1r | 38 | 1w | 38 |
| *Upper North Fork Crazy Women Creek* | *17* | *251* | *2,572* | *1r* | *13* | *2w* | *15* |
| *Upper Canyon Creek-Tensleep Creek* | *1* | *77* | *1,145* | *2r* | *31* | *2w* | *31* |
| Lower Tensleep Creek | | 0.5 | 964 | 5r | 25 | 4w | 25 |
| *Leigh Creek* | *1* | *7* | *872* | *2r* | *28* | *2w* | *28* |
| **TOTAL:** | **2,541** | **3,020** | **68,341** | **1r – 6r** | **1 – 67** | **1w – 6w** | **1 – 67** |

- Acreage discrepancies are due to GIS calculations and rounding errors. Note that two 6$^{th}$-level watersheds intersect multiple project areas, and therefore are repeated in the table above.

Six riparian/wetland clusters, as described by Winters et al. (2004), are found in the analysis area. The cluster associated with each watershed is shown in the table above. Each cluster has a distinct signature represented by spatial variations in geology, climate, and Pleistocene glaciation (Winters et al. 2004). Watersheds within riparian/wetland cluster 2 are the most sensitive to anthropogenic activities; but in general, sensitivity decreases from cluster 1 to cluster 6. The table above also shows the riparian/wetland rank of the watershed when all anthropogenic influences are considered. Watersheds that have a low rank (out of the 74 total 6th-level watersheds on the BNF) are more susceptible to anthropogenic activities.

Riparian cluster 1r is dominated by high elevation, high gradient streams, with non-calcareous geology and a snow-driven precipitation regime. The majority of riparian areas within this cluster are related to perennial stream channels. Relative to the six total riparian clusters, this cluster has a high potential to be influenced by anthropogenic activities. Management considerations for this cluster include: 1) developing reference conditions and relative impacts for vegetation and physical characteristics activities and 2) riparian vegetation is a key emphasis for restoration activities (Winters et al. 2004).

Riparian cluster 2r is dominated by calcareous geology with a snow/rain-and-snow hydrologic regime, and streams have moderate to high gradients with abundant low gradient reaches. This cluster has the highest potential to be influenced by anthropogenic activities, in relation to the six riparian clusters. Management considerations for this cluster include: 1) manage for native fish and riparian communities, 2) consider watershed restoration, and 3) understand reference conditions (Winters et al. 2004).

Riparian cluster 3r, primarily located on the eastern flanks of the Big Horn Mountains, is dominated by non-calcareous geology, high gradient streams (with localized, low gradient reaches), and a rain-and-snow precipitation regime. Relative to the other riparian clusters, cluster 3r has a high potential to be influenced by anthropogenic activities. Management considerations for this cluster include: 1) stream restoration, 2) identify reference conditions in streams with relatively few anthropogenic influences, and 3) manage ground-disturbing activities to minimize sediment movement in valley bottoms with steep gradients (Winters et al. 2004).

Riparian cluster 4r, located primarily at high elevations on the northern side of the Big Horn Mountains, is underlain with calcareous bedrock, has high gradient streams, and is dominated by a snow-driven precipitation regime. This cluster has a moderate potential to be influenced by anthropogenic activities, relative to the other clusters. Management considerations are not as important for this cluster because these watersheds have a low potential to be affected by human influence (Winters et al. 2004).

Riparian cluster 5r occurs along the mountain front on the western and northern sides of the Bighorns. Watersheds in this cluster are largely calcareous, with rain-and-snow precipitation regimes and abundant low/moderate gradient streams. Cluster 5r has a moderate to low potential of anthropogenic influence, relative to the other five riparian clusters. Management considerations for this cluster are minimal, as only a small portion of the watersheds are within the BNF boundary; considerations include: 1) mitigate projects effecting downstream resources and 2) springs.

Riparian cluster 6r primarily has non-calcareous bedrock, rain-driven precipitation regimes, and low gradient streams found in the far eastern and northwestern portion of the forest. This cluster has the lowest potential to be influenced by anthropogenic activities, in relation to the other riparian clusters. Management considerations include: 1) maintaining water quality in downstream municipal watersheds and 2) springs and rare plants (Winters et al. 2004).

The majority of wetland cluster 1w consists of high altitude glaciated valleys, non-glaciated ridgelines, non-calcareous bedrock (granitic and gneissic), and a predominately snow-driven precipitation regime. Cluster 1w is sensitive to management activities that alter the sediment or hydrologic regime. Management considerations include restoration and protection of wetlands to maintain biodiversity and habitat diversity (Winters et al. 2004).

Wetland cluster 2w is comprised predominately of high elevation, non-glaciated terrain that is underlain by non-calcareous geology. This cluster comprises the largest proportion of groundwater-fed wetlands within the Bighorn National Forest. From a wetland ecosystem perspective, this cluster has the highest potential to be influenced by anthropogenic activities, as it contains the largest proportion of groundwater-fed wetlands within the BNF. Management considerations for this cluster include: 1) strategic wetland protection and management and 2) wetland restoration (Winters et al. 2004).

Wetland cluster 3w is largely non-calcareous, non-glaciated, has a rain-and-snow driven precipitation regime, and mainly supports stream-related riparian ecosystems, with very few groundwater-fed wetlands. Sensitive to fluctuations in surface water hydrology, this cluster has a high potential to be influenced by anthropogenic activities. Management considerations consist of: 1) restoration of individual wetlands, because wetlands in this cluster are small and isolated, 2) identify rare species, and 3) maintain connectivity across the landscape (Winters et al. 2004).

Wetland cluster 4w occupies most of the southwestern portion of the Big Horn Mountains. This cluster has predominately calcareous, non-glaciated geology and has a rain-and-snow precipitation regime. The watersheds in this cluster support only a small wetland ecosystem area, and are sensitive to fluctuations in surface water hydrology and sedimentation. Relative to the other six wetland clusters, cluster 4w has a lower potential to be influenced by anthropogenic activities. Management considerations include: 1) maintain integrity of wetlands, as they are isolated and small in this cluster and 2) springs and associated flora (Winters et al. 2004).

Wetland cluster 5w occupies the north-central portion of the Big Horn Mountains and has predominately calcareous geology, non-glaciated valleys, and a snow-driven precipitation regime. Low gradient valleys contain a large percentage of lakes, meadows, and groundwater-fed wetlands, which are sensitive to fluctuations in sediment and the hydrologic regime. Relative to the other wetland clusters, cluster 5w has a moderate to high potential to be influenced by anthropogenic activities. Management considerations include: 1) map wetland habitats and associated rare plants and animals and 2) consider human activities that influence vegetation and water quality (Winters et al. 2004).

Wetland cluster 6w has both calcareous and non-calcareous bedrock, unglaciated valleys, and occurs at low elevations with hydrologic regimes driven by rain and rain-and-snow precipitation. Stream valley associated wetlands are most common, and therefore are most sensitive to sediment and surface water fluctuations. This cluster has a moderate potential to be influenced by anthropogenic activities, and should be managed to consider springs and rare wetland plant species (Winters et al. 2004).

Wetland cluster 7w occupies low elevations, primarily on the eastern flanks of the Big Horn Mountains, and has non-calcareous geology, non-glaciated valleys, and rain-driven precipitation regimes. The few existing wetlands in this cluster are related to stream reaches and are sensitive to fluctuations in sediment and surface water. Cluster 7w has the lowest potential to be influenced by anthropogenic activities, relative to the other wetland clusters. Management considerations include: 1) springs and rare plants and 2) inventory existing wetlands.

In summary, the riparian and wetland clusters discussed above indicate that some watersheds comprising the analysis area are sensitive to anthropogenic activities (9 out of 31 watersheds). Watersheds within riparian/wetland cluster 2 (most sensitive) include: Leigh Creek, Little Bighorn River-Wagon Box Creek, Upper Canyon Creek-Tensleep Creek, Upper Medicine Lodge Creek, Upper North Fork Crazy Women Creek, and Upper Quartz Creek watersheds. Furthermore, Lower East Fork Big Goose watershed, Upper Little Goose watershed, and Paint Rock Creek-South Paint Rock Creek watershed are most sensitive to anthropogenic activities, given their low riparian/wetland ranks of 1, 8, and 9, respectively (out of 74). Although some watersheds in the analysis area are sensitive to anthropogenic influences, the proposed action is designed to minimize effects to riparian areas, wetlands, and waterbodies. The proposed action addresses the management considerations described by Winters et al. (2004) through BMPs, grazing rotations, and other design criteria.

## Geology and Soils (Issue 3)

Geology in the analysis area is characterized primarily by granite, with sedimentary lithologies located along the forest boundary. The Precambrian granitic core of the Big Horn Mountains consists of coarse-grained red granite and medium-grained to fine-grained gray granite. Glaciation occurred during the Pleistocene and covered the highest elevations of the Big Horns. Glacial features, including moraines, outwash, and till, remain today and cover portions of the project area. The table below lists the acres of lithology, based on the 31 watersheds comprising the analysis area within the Bighorn National Forest boundary.

**Table 7. Acres of lithology found within the analysis area watersheds (on forest only). Data derived from GIS analysis of Soil Map Unit and BNF data.**

| Lithology | Analysis area acres |
|---|---|
| Alluvium | 6,717 |
| Glacial Moraine | 13,663 |
| Glacial Outwash | 2,466 |
| Granite | 257,318 |
| Glacial Till | 23,233 |
| Landslide Deposit | 19,226 |
| Limestone | 189,508 |
| Siltstone | 208 |
| Sandstone | 14,083 |
| Mixed Sedimentary | 44,098 |
| **Total:** | **570,520** |

- Acreage discrepancies are due to GIS calculations and rounding errors.

Soils are a function of parent material, climate, organisms, topography, and time. Existing soil conditions within the project area were analyzed using summaries provided in the Soil Survey of the Bighorn National Forest, Wyoming (Nesser 1986). Each soil series includes detailed map units (MUs) representing a distinctive pattern of soils, relief, and drainage. Each MU has a unique set of soil properties and the soil survey contains useful predictions of soil behavior, suitability, limitations, and potential of a MU for selected land uses. Soil types and properties found within the project area are summarized in the following table. Nesser (1986) describes each soil association in detail while the table below summarizes each association's limitations to grazing.

For map units that were not analyzed by Nesser's 1986 Bighorn National Forest soil survey (MUs greater than 43), the Natural Resources Conservation Service Official Soil Series Descriptions database (NRCS 2009) was assessed. While the NRCS database does not specifically identify limitations to livestock grazing for soil associations, these MUs comprise only a small proportion of the project area (2%). MUs not addressed in the BNF soil survey are located on the northeast and southwest margins of the forest boundary.

The table below was updated after receiving Tommy John's comments about plant associations, to identify which soil types are likely to have grazing on them.

**Table 8. Soil types within the project area (PA) allotments and their limitations to livestock grazing. Sensitive soil types are in bold/italicized. Data derived from GIS analysis of Soil Map Unit (MU) and BNF data. Limitations of MUs 1-43 were derived from Soil Survey of the Bighorn National Forest (Nesser 1986) and descriptions of MUs greater than 43 were derived from the NRCS Official Series Descriptions database (NRCS 2009).**

| Soil association | Map unit | Acres within PA | % of PA | Soil limitations to livestock grazing | Plant association |
|---|---|---|---|---|---|
| Agneston | 10,11 | 95,302 | 24% | Steepness of slope, rock outcrop | Lodgepole pine, Engelmann spruce, grouse whortleberry |
| Rock Outcrop | 31,32,33, 34,35,36 | 71,916 | 18% | Steepness of slope, exposed rock, alpine climate, droughtiness, short growing season | Rock outcrop: supports little if any vegetation<br>Lodgepole pine, grouse whortleberry, Douglas fir, mountain ninebark, alpine vegetation, Idaho fescue, sedge, mountain mahogany, bluebunch wheatgrass, |

| Soil association | Map unit | Acres within PA | % of PA | Soil limitations to livestock grazing | Plant association |
|---|---|---|---|---|---|
| | | | | | Engelmann spruce |
| Cloud Peak | 14,15 | 62,060 | 16% | Steepness of slope | Douglas fir, mountain ninebark, Engelmann spruce, grouse whortleberry, bluebunch wheatgrass |
| Nathrop | 27, 28 | 26,548 | 7% | Droughtiness | Idaho fescue, silky lupine, sedge |
| Frisco-Troutville | 19A,19B | 21,843 | 6% | Boulders, steepness of slope | Lodgepole pine, grouse whortleberry |
| Tongue River-Gateway Leslie- please un-bold and un-italicize this row in the EIS | 43 | 15,070 | 4% | Mass movements, high shrink-swell potential, and hazard of erosion ~~place limitations on timber harvest~~ | Lodgepole pine, Engelmann spruce, grouse whortleberry |
| Owen Creek-Echemoor-Bynum | 29 | 14,815 | 4% | No major limitations for forage production (common mass movement requires careful road location/construction) | Big sagebrush, Idaho fescue |
| Starman-Starley | 39 | 13,228 | 3% | Droughtiness | Idaho fescue, sedge |
| Lucky-Burgess-Hazton | 25 | 11,324 | 3% | Droughtiness | Idaho fescue, sedge |
| ***Owen Creek–Waybe*** | ***30*** | ***7,722*** | ***2%*** | ***Hazard of erosion, droughtiness*** *(mass movement and high shrink-swell requires careful road location/construction)* | ***Big sagebrush, Idaho fescue*** |
| Hanson | 21, 22 | 7,599 | 2% | Droughtiness | Idaho fescue, silky lupine, bluebunch wheatgrass, sedge |
| Rubble land | 37 | 6,582 | 2% | Steepness of slope, alpine climate | Supports little, if any vegetation |
| Sapphire-Bottle-Foxton | 38 | 5,634 | 1% | Droughtiness, high shrink-swell potential | Lodgepole pine, grouse whortleberry |
| Tellman-Granile-Agneston | 40 | 5,451 | 1% | No major limitations | Lodgepole pine, grouse whortleberry |
| Cloud Peak-Tolman | 91 | 3,683 | 1% | Steepness of slope for Cloud Peak, droughtiness of Tolman | Douglas fir, Engelmann spruce, mountain ninebark, bluebunch wheatgrass, prairie junegrass |
| Mirror-Teewinot-Bross | 26 | 2,555 | 1% | Alpine climate, short growing season | Alpine vegetation |
| ***Cryaquolls*** | ***16*** | ***3,257*** | ***0.8%*** | ***Frequent flooding, poor drainage*** | ***Tufted hairgrass, alpine timothy*** |
| Farlow-Pishkun | 17 | 1,851 | 0.5% | No major limitations for forage production (some mass movement requires careful road location/construction) | Big sagebrush, Idaho fescue |
| Chittum, Limber-Hyattville, Nathrop-Starley Spearfish-Travessilla, Whaley, Woosley-Starley, Abac, Norbert-Doney Rock outcrop | 63,71,74, 77,80,83, 90,97,98 | 1,830 | 0.5% | Steepness of slope, exposed rock, droughtiness | Nathrop: Idaho fescue, silky lupine<br>Starley: Idaho fescue, sedge<br>Spearfish: Utah juniper, big sagebrush<br>Rock outcrop: supports little if any vegetation<br>All others: unknown |
| Inchau - Carbol | 23 | 1,655 | 0.4% | Droughtiness | Idaho fescue, sedge |
| Tine-Fourmile | 41A,41B | 1,579 | 0.4% | No major limitations | Big sagebrush, Idaho fescue, silky lupine |

| Soil association | Map unit | Acres within PA | % of PA | Soil limitations to livestock grazing | Plant association |
|---|---|---|---|---|---|
| ***Leavitt-Passcreek*** | ***24*** | ***1,532*** | ***0.4%*** | ***Hazard of erosion*** | ***Idaho fescue, silky lupine*** |
| ***Tolman-Beenom-Carbol*** | ***42*** | ***1,514*** | ***0.4%*** | ***Droughtiness, hazard of erosion*** | ***Bluebunch wheatgrass, prairie junegrass*** |
| Fourmile | 18 | 1,482 | 0.4% | No major limitations | Idaho fescue, silky lupine |
| Hardhart-Starley | 93 | 1,059 | 0.3% | Hardhart limitations unknown, droughtiness of Starley | Hardhart: unknown<br>Starley: Idaho fescue, sedge |
| Woosley-Decross-Morset | 81, 82 | 853 | 0.2% | Limitations unknown | Unknown |
| Cirque land | 13 | 779 | 0.2% | Steepness of slope, alpine environment | Supports little, if any vegetation |
| Chilton-Sunup-Spearfish | 12 | 566 | 0.1% | Droughtiness | Utah juniper, big sagebrush |
| Coutis-Greenman | 67 | 418 | 0.1% | Limitations unknown | Unknown |
| ***Tolman-Beeno-Beenom*** | ***99*** | ***354*** | ***0.1%*** | ***Droughtiness of Tolman, erosion hazard of Beenom*** | ***Bluebunch wheatgrass, prairie junegrass*** |
| Grobutte | 20 | 255 | 0.1% | No major limitations | Black sagebrush, bluebunch wheatgrass |
| Vale-Tensleep | 79 | 203 | 0.1% | Limitations unknown | Unknown |
| Greenman-Splitro | 70 | 146 | 0.04% | Limitations unknown | Unknown |
| Billycreek-Wetterhorn | 62 | 106 | 0.03% | Limitations unknown | Unknown |
| Stubbs-Turk | 78 | 61 | 0.02% | Limitations unknown | Unknown |
| Clayburn-Wallrock | 65 | 41 | 0.01% | Limitations unknown | Unknown |
| Clayburn-Bachus-Inchau | 64 | 37 | 0.01% | Limitations unknown | Clayburn and Bachus: unknown<br>Inchau: Idaho fescue, sedge |
| Norbert-Doney-Rock outcrop | 97, 98 | 28 | 0.01% | No major limitations | Unknown |
| Forkwood-Kishona | 69 | 22 | 0.01% | Limitations unknown | Unknown |
| ***Nesda*** | ***95*** | ***0.6*** | ***0.0001%*** | ***Frequent flooding*** | ***Bluebunch wheatgrass, needleandthread, prairie sandreed, forbs, shrubs*** |
| TOTAL: | | 390,934 | | | |

- Acreage discrepancies are due to GIS calculations and rounding errors.

The table above identifies the plant association for each soil type within the project area allotments. The plant association distinguishes between soils dominated by forests and those that are non-forested. Non-forested soils are where the majority of livestock grazing occurs. Whereas forested soils may be affected by livestock trailing, and in general, livestock spend a low amount of time on forested soil types and the effects to forested soil types are correspondingly low.

### *Sensitive Soils*

These changes were made based on Tommy John's comments. Tongue-River Gateway soil is NOT sensitive to grazing because this soil type is forested.

~~Seven~~ Six soil associations within the project area are sensitive to grazing activities: ~~Tongue-River Gateway~~, Owen Creek-Waybe, Cryaquolls, Leavitt-Passcreek, Tolman-Beenom-Carbol, Tolman-Beeno-Beenom, and Nesda. ~~Six~~ Five soil types were identified as sensitive by Nesser's 1986 Bighorn National Forest soil survey, and one additional soil type was determined to be sensitive by reviewing the NRCS Official Soil Series Descriptions database (NRCS 2009).

Altogether, soils that are sensitive to livestock grazing comprise approximately ~~7.7~~ 3.7% (~~29,450~~ 14,380 acres) of the project area allotments.

~~Tongue River-Gateway (MU 43) soils are found on mountainsides. Tongue River soil have a moderate to severe hazard of water erosion and Gateway soils have frequent mass movements and a high shrink-swell potential (Nesser 1986). This soil association comprises 4% of the total project area allotments, and is found in the Beaver Creek area (near the very headwaters of North Beaver Creek, South Beaver Creek, and Cedar Creek), Little Horn area (near the headwaters of Wagon Box Creek, Little Bighorn River, Lick Creek, and Lake Creek), and the Tensleep area (near Leigh Creek and Canyon Creek, and to the east of Tensleep Ceek). However, the Tongue River-Gateway soil is dominated by Lodgepole pine, Engelmann spruce, and grouse whortleberry. Therefore, it is not likely to be heavily used by livestock.~~

Owen Creek-Waybe (MU 30) soils are commonly found on moderately stable to unstable landslide deposits. These soils are shallow to moderately deep, well drained, are derived from shale and limestone, and comprise 2% of the project area. Owen Creek-Waybe soils are located in the Goose Creek area (along Wolf Creek), Beaver Creek area (along the headwaters of Bear Creek, North Beaver Creek headwaters and southwest-flowing tributaries, and the headwaters of Cedar Creek), Little Horn area (along Wagon Box Creek, Lick Creek, Lake Creek, Miller Creek, and the Little Bighorn River), and Tensleep area (along Spring Draw and of the majority of Tensleep Creek). The permeability of Waybe soils is slow and therefore has a moderate to severe water erosion hazard. Forage production is low on these soils due to their droughtiness and the erosion hazard necessitates careful grazing management (Nesser 1986).

Cryaquolls (MU 16) are typically associated with riparian areas that have frequent flooding and poor drainage. This soil association is found in all five Big 6 project areas, along stream corridors, but is predominately located in the Goose Creek and Tensleep project areas. In the Goose Creek area, Cryaquolls are primarily found along Gloom Creek, Sawmill Creek, Snail Creek, Ranger Creek, Babione Creek, Antler Creek, East Fork Big Goose Creek, and Cross Creek. Cryaquolls are dominant along Tensleep Creek, West Tensleep Creek, Lake Creek, East Tensleep Creek, Baby Wagon Creek, and tributaries to Canyon Creek, in the Tensleep project area. Although Cryaquolls occupy a small percentage of the total project area (0.8%), they are easily compacted or displaced by land-disturbing activities such as livestock grazing (Nesser 1986). Limiting the timing of activities to the summer months, when soils are drier, and implementing a grazing strategy that does not allow livestock to spend extended periods of time in riparian areas could help reduce effects.

Leavitt-Passcreek (MU 24) soils are located on mountainsides, toe slopes, and fans, and are moderately deep and well drained. This soil association comprises 0.4% of the total project area and is found in the Beaver Creek area (along Grouse Creek), the Little Horn area (scattered in the north along tributaries to the Dry Fork Little Bighorn River and West Fork Little Bighorn River), and the Tensleep area (along South Fork Brokenback Creek and Stovepipe Creek). The permeability of the Leavitt soils is moderately slow and the resulting hazard of erosion requires careful grazing management on this soil type (Nesser 1986).

Tolman-Beenom-Carbol (MU 42) soils are located on mountainsides and toe slopes. This association is shallow to moderately deep and is well drained. The hazard of water erosion of the Beenom and Carbol variants is moderate to severe, requiring careful grazing management (Nesser 1986). This soil type occupies 0.4% of the total project area and is found near the forest boundary in the Little Horn area (Eskimo Creek, tributaries to the West Fork Little Bighorn River, and tributaries to Red Canyon Creek) and the Rock Creek area (Johnson Creek).

Tolman-Beeno-Beenom (MU 99) soils were determined to be sensitive to livestock grazing because the Beenom variant has a moderate to severe hazard of water erosion (Nesser 1986).

This soil type comprises 0.1% of the total project area and is found along the forest boundary in the Little Horn area (tributary to Elkhorn Creek and tributary to Red Canyon Creek) and Goose Creek area (tributary to Bear Gulch and tributaries to Big Goose Creek).

Nesda (MU 95) soils are not discussed in the Nesser (1986) soil survey of the Bighorn National Forest, and therefore, limitations to grazing were not directly identified. However, it was determined in the NRCS soil series database (2009) that this association is associated with floodplains and stream terraces. As a result, such locations are close to the water table and are subject to frequent flooding, especially during spring runoff. Although Nesda soils only comprise 0.0001% of the project area, it is important to limit grazing activity to times when soils are dry. These soils are found along the West fork of the Little Bighorn River, right at the forest boundary.

The Tongue River Gateway column in the table below was deleted because this soil is sensitive to timber harvest, not livestock grazing. Two allotments were added that were previously left out, which also changed total acres in table.

**Table 9. Acres of sensitive soils by project area allotment.**

| Allotment | Cryaquolls (16) | Leavitt-Passcreek (24) | Owen Creek-Waybe (30) | Tolman-Beenom-Carbol (42) | ~~Tongue River-Gateway (43)~~ | Nesda (95) | Tolman-Beeno-Beenom (99) |
|---|---|---|---|---|---|---|---|
| **Beaver Creek Project Area** | | | | | | | |
| Antelope Ridge S&G | | | 73 | | ~~473~~ | | |
| Bear/Crystal Creek S&G | | | 469 | | ~~9~~ | | |
| Beaver Creek S&G | | | 423 | | ~~106~~ | | |
| Finger Creek C&H | | | | | | | |
| Grouse Creek S&G | | 160 | | | | | |
| Hunt Mountain S&G | | | 889 | | ~~638~~ | | |
| Little Horn S&G | 41 | | 639 | | ~~1556~~ | | |
| Matthew's Ridge C&H | | | | | | | |
| Red Canyon C&H | | | | | | | |
| Red Canyon S&G | | | | | | | |
| South Park C&H | | | | | | | |
| Sunlight Mesa C&H | | 190 | | | | | |
| Whaley Creek S&G | 28 | | 175 | | ~~5~~ | | |
| Wiley Sundown C&H | | | | | - | | |
| **Goose Creek Project Area** | | | | | | | |
| Big Goose C&H | 400 | | | | | | |
| Little Goose C&H | 195 | | | | | | |
| Little Goose Canyon C&H | | | | | | | |
| Rapid Creek C&H | 149 | | | | | | 121 |
| Stull Lakes C&H | 361 | | | | | | |
| Tourist Horse GRA | 258 | | | | | | |
| Walker Prairie C&H | 162 | | 260 | | - | | |
| **Little Horn Project Area** | | | | | | | |
| Dry Fork Ridge C&H | | | 0.1 | 198 | | | 233 |
| Fisher Mountain C&H | | | | 179 | | 0.4 | |

| Allotment | Cryaquolls (16) | Leavitt-Passcreek (24) | Owen Creek-Waybe (30) | Tolman-Beenom-Carbol (42) | ~~Tongue River-Gateway (43)~~ | Nesda (95) | Tolman-Beeno-Beenom (99) |
|---|---|---|---|---|---|---|---|
| Lake Creek C&H | | | 731 | | ~~3244~~ | | |
| Little Horn C&H | | | 2546 | | ~~3334~~ | | |
| Lower Dry Fork C&H | | 33 | 585 | | ~~358~~ | | |
| Red Springs C&H | | 177 | | 1019 | | 0.1 | |
| Sage Basin C&H | | | 58 | | ~~151~~ | | |
| West Pass C&H | | | 111 | | ~~204~~ | | |
| Wyoming Gulch C&H | 199 | | 154 | | ~~1630~~ | | |
| **Rock Creek Project Area** | | | | | | | |
| Rock Creek C&H | 77 | | | 118 | - | | |
| **Tensleep Project Area** | | | | | | | |
| Baby Wagon S&G | 282 | | | | | | |
| Battlepark C&H | 18 | | 32 | | ~~7~~ | | |
| Crazy Woman S&G | | | | | | | |
| Dry Tensleep C&H | 4 | 722 | | | | | |
| Garnet Creek S&G | 140 | | | | ~~0.1~~ | | |
| Hazelton S&G | 128 | | | | | | |
| Leigh Creek S&G | 110 | | | | | | |
| McLain Lake S&G | 202 | | | | | | |
| Monument C&H | | | | | | | |
| North Canyon C&H | 13 | 250 | 569 | | ~~1551~~ | | |
| South Canyon C&H | 32 | | | | ~~1802~~ | | |
| Tensleep Canyon C&H | | | 8 | | ~~1~~ | | |
| Upper Meadows S&G | 286 | | | | | | |
| Willow S&G | 172 | | | | - | | |
| **Total** | **3,257** | **1,532** | **7,722** | **1,514** | **~~15,070~~** | **0.6** | **354** |

Effects analysis of livestock grazing specific to suitable acres does not occur within this report. Sensitive soils occur outside the boundaries of suitable acres and livestock grazing occurs on acreage not identified as suitable range; therefore, effects to soils from livestock grazing are analyzed within the entire project area, not specific to suitable acres. In addition, a more detailed analysis occurs on non-forested soils within the allotment boundaries.

A century of livestock grazing, prior to the implementation of current AMPs, contributed heavily to soil compaction and soil disturbance present in the allotment boundaries. Livestock grazing was much less regulated in the past and caused damage that is still evident today.

### *Site-Specific Soils*

The following section identifies specific areas of soil concerns within the project area allotments. These areas were identified by the range conservationists on all three districts, within non-forested acres, totaling 141 acres within the Big 6 project area.

### Powder River Ranger District (20 acres)

- Tensleep Canyon Allotment - North Willow Pasture riparian corridor (Dry Tensleep Creek at PP-01): approximately 2 acres, with some areas of compacted, eroded, and bare soil. Additional water points have been added to draw livestock out of affected riparian area. Photo point monitoring is in place. Adaptive management strategies include a new fence to split the pasture to better distribute livestock.
- Leigh Creek Allotment – sheep driveway: approximately 2 acres, with some areas of bare soil, pedestalling, and erosion. This site was impacted by historic livestock grazing and is improving under current management (lighter stocking, shorter grazing season, deferred rotation, herding, etc.). CF-01 was established to specifically monitor this site.
- Garnet Creek Allotment – sheep driveway: approximately 2 acres, with some areas of bare soil, pedestalling, and erosion. This site was impacted by historic livestock grazing and is improving under current management (lighter stocking, shorter grazing season, deferred rotation, herding, etc.). There are several photo points in place to monitor this area.
- North Canyon Allotment – Teepee Creek riparian area: approximately 5 acres, with some areas of soil erosion and bare soil. This area is being addressed with fences and additional water sources.
- North Canyon Allotment – Meadowlark riparian area: approximately 3 acres, with some areas of compaction, hummucking, and erosion. This area is being addressed with fences and/or additional water sources.
- Upper Meadows Allotment – near East Tensleep Creek: approximately 2 acres, with some areas of pedestals, rills, erosion, and bare soil. CF-01 was established to monitor improvement of this site under current management (lighter stocking, shorter grazing season, deferred rotation, herding, etc.).
- South Canyon Allotment – north Leigh Creek drainage: approximately 2 acres, with some areas of soil compaction. Several photo points have been established to monitor this location, in addition to proposed fences and water developments, and implementing deferred rotation.
- South Canyon Allotment – south Leigh Creek drainage: approximately 2 acres, with some areas of bare soil, gullies, and erosion. This area is being addressed with deferred rotation and proposed fences. Photo points have been established to monitor soil improvement.

### Tongue River Ranger District (31 acres)

Note that the acreage figures for the locations below are not contiguous. For example, Quartz Creek is comprised of several smaller areas that stretch along a total 1.5 mile length.

- Lamburger Rock (T53N, R86W, NW1/4 S13) - approximately 1.5 acres of hummocking. This area is being addressed with allowable use guidelines. Current management over the last 10 years has been facilitating recovery of soils at this location.
- Ranger Creek (T54N, R86W, SE1/4 S32) - approximately 2.5 acres of hummocking. This area is being addressed with allowable use guidelines. Current management over the last 10 years has been facilitating recovery of soils at this location.

- Babione Creek (T53N, R86W, SW1/4 S9) - approximately 1 acre of hummocking. This area is being addressed with allowable use guidelines. Current management over the last 10 years has been facilitating recovery of soils at this location.
- Poverty Flats (T54N, R85W, SE1/4 S28) - approximately 1 acre of hummocking and bare soil. This area is being addressed with allowable use guidelines and the installation of barriers to limit livestock access to this location.
- Buck Creek (T54N, R86W, NW1/4 S6) - approximately 7 acres of bare soil. This area is being addressed with allowable use guidelines and the installation of fence to limit livestock access to this location.
- Quartz Creek (T54N, R87W, NW1/4 S25, SE1/4 S23) - approximately 2 acres of bare soil. This area is being addressed with allowable use guidelines and the installation of fence to create up to 3 pastures to better distribute livestock in this area. Current management over the last 10 years has been facilitating recovery of soils at this location.
- Bear Trap (T56N, R90W, SW1/4 S7) - approximately 8 acres of bare soil. This area is being addressed with allowable use guidelines. Current management over the last 10 years has been facilitating recovery of soils at this location.
- Dry Fork Ridge (T57N, R89W, center of S15) - approximately 8 acres of bare soil and rilling. This area is being addressed with allowable use guidelines. Current management over the last 10 years has been facilitating recovery of soils at this location.

### Medicine Wheel/Paintrock Ranger District (90 acres)

- Three riparian areas (T57N, R91W) in the Red Springs C&H allotment are not meeting or moving toward desired conditions. These areas exhibit hummocking, portions of bare soil, and an overall historic loss of soil. Photo point monitoring is in place at all three locations. The proposed action for this allotment would reduce the stocking rate by approximately 30% through a combination of fewer livestock numbers and a shorter season of use. Even in the absence of grazing or reductions in stocking, it is unknown to what degree the sites may recover due to the existing loss of soils.
    - Mann Creek – headwaters to approximately 1.5 miles downstream (5 acres)
    - Cub Creek – headwaters to approximately 0.5 miles downstream (2 acres)
    - Pumpkin Creek – headwaters to approximately 0.75 miles downstream (3 acres)
- Two upland areas in the Red Springs C&H allotment (T57N, R91W, S2 and S3) are not meeting or moving toward desired conditions. These areas have been impacted by historic livestock use, and a high concentration of historic and current rodent activity. These locations have areas of bare soil and have very few desirable or intermediate plant species present. Long-term trend monitoring is in place and indicates that these areas are in poor condition. The proposed action for this allotment would reduce the stocking rate by approximately 30% through a combination of fewer livestock numbers and a shorter season of use.
    - Upland area adjacent to headwaters of Pumpkin Creek (approximately 40 acres)
    - Upland area in Sheepherder Draw (approximately 40 acres)

## Fisheries (Issue 6)

Brook trout (BKT) are the dominant species (most abundant) in the analysis area and project area perennial streams and lakes, followed by rainbow trout (RBT). The distribution of dominant fish species is shown in the following table.

**Table 10. Dominant fish species in the analysis area (AA) (on forest only) and project area (PA); data derived from BNF fish GIS data.**

| Dominant Fish Species | Miles of Perennial Stream | | Acres of Lake | |
|---|---|---|---|---|
| | Within AA (watersheds on forest) | Within PA (allotments) | Within AA (watersheds on forest) | Within PA (allotments) |
| **RBT** | 107 | 81 | 764 | 86 |
| **YCT** | 24 | 13 | 192 | 0 |
| **SRC** | 0 | 0 | 32 | 18 |
| **BKT** | 289 | 157 | 922 | 550 |
| **BNT** | 18 | 13 | 20 | 9 |
| **GDT** | 0 | 0 | 37 | 0 |
| **None present** | 133 | 105 | 615 | 418 |
| **RXC** | 4 | 4 | 0 | 0 |
| **Unknown** | 78 | 68 | 169 | 102 |
| **GRL** | 0 | 0 | 34 | 34 |
| **Total** | **653** | **441** | **2,785** | **1,218** |

- rainbow trout (RBT), Yellowstone cutthroat trout (YCT), Snake River cutthroat trout (SRC), brook trout (BKT), brown trout (BNT), golden trout (GDT), rainbow trout-cutthroat trout hybrid (RXC), grayling (GRL)
- Acreage discrepancies are due to GIS calculations and rounding errors.

Electro-fishing evaluations conducted by the Wyoming Game and Fish Department (WGFD) and BNF personnel indicate that brook trout (BKT), brown trout (BNT), grayling (GRL), rainbow trout (RBT), Yellowstone cutthroat trout (YCT), grayling (GRL), Snake River cutthroat trout (SRC), and rainbow trout/cutthroat trout hybrid (RXC) have been and are currently present in the project area. These data were compiled from the WGFD River Station databases (Sheridan Region version dated 02 Feb 2010 and Cody Region version dated 03 Feb 2010). The tables below give the date, location, mean length, and number of fish per mile from the two most recent sampling dates per station in the project area.

**Table 11. Fish population estimates in the Beaver Creek Project Area. Numbers in parenthesis represent mean length in inches. No fish were collected during sampling at the Cottonwood Creek site on 13-Aug-2010.**

| | North Beaver Creek | Cottonwood Creek |
|---|---|---|
| **Location** | T53 R86 S3 | T54 R90 S27 NW |
| **Elevation (ft)** | 6430 | 8202 |
| **Date** | 4-Aug-1998 | 13-Aug-1996 |
| **Sampled length (ft)** | 374 | 150 |
| **BKT/mi** | 88 (6.0) | 0 |
| **BKT/mi >6in** | 59 | 0 |
| **RBT/mi** | 42 (8.2) | 0 |
| **RBT/mi>6in** | 42 | 0 |
| **RXC/mi** | 28 (7.5) | 0 |
| **RXC/mi >6in** | 28 | 0 |
| **YCT/mi** | 127 (7.2) | 0 |
| **YCT/mi >6in** | 102 | 0 |

**Table 12. Fish population estimates in the Goose Creek Project Area. Numbers in parenthesis represent mean length in inches.**

| | East Fork Big Goose Creek | | Gloom Creek | East Fork Little Goose Creek | | West Fork Little Goose Creek | Quartz Creek | |
|---|---|---|---|---|---|---|---|---|
| **Location** | T53 R86 S3 | T53 R86 S3 | T55 R87 S23 NESW | T53 R85 S4 | T53 R85 S4 | T53 R85 S4 | T55 R87 S23 NWSE | T55 R87 S23 SENE |
| **Elevation (ft)** | 7600 | 7560 | 7350 | 7560 | 8670 | 7510 | 7350 | 7644 |
| **Date** | Aug-20-90 | Oct-02-95 | 10-Sep-2001 | 28-Aug-2001 | 29-Aug-2001 | 28-Aug-2001 | 11-Sep-2001 | 12-Sep-2001 |
| **Sampled length (ft)** | 528 | 383 | 328 | 328 | 328 | 328 | 328 | 328 |
| **BKT/mi** | 1506 (4.5) | 621 (5.5) | 2655 (5.1) | 0 | 0 | 4780 (5.1) | 4522 (5.4) | 3009 (5.0) |
| **BKT/mi >6in** | 478 | 151 | 789 | 0 | 0 | 901 | 1802 | 708 |
| **BNT/mi** | 644 (6.8) | 1630 (7.2) | 0 | 0 | 0 | 0 | 0 | 0 |
| **BNT/mi >6in** | 338 | 1248 | 0 | 0 | 0 | 0 | 0 | 0 |
| **GRL/mi** | 0 | 124 (8.7) | 0 | 0 | 0 | 0 | 0 | 0 |
| **GRL/mi >6in** | 0 | 124 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RBT/mi** | 608 (5.9) | 682 (7.4) | 0 | 1802 (5.9) | 274 (8.3) | 0 | 0 | 0 |
| **RBT/mi >6in** | 254 | 582 | 0 | 1014 | 241 | 0 | 0 | 0 |

**Table 13. Fish population estimates in the Little Horn Project Area. Numbers in parenthesis represent mean length in inches.**

| | Dayton Gulch Creek | Duncum Creek | Lake Creek | | Lick Creek | |
|---|---|---|---|---|---|---|
| **Location** | T56 R91 S12 | T57 R90 S30 | T57 R89 S27 | | T57 R89 S28 | |
| **Elevation (ft)** | 7000 | 8400 | 8640 | | 8500 | |
| **Date** | 27-Aug-1985 | 13-Aug-1958 | 31-Jul-1986 | 17-Jul-1987 | 15-Jul-1998 | 14-Jul-1999 |
| **Sampled length (ft)** | 264 | 264 | 825 | 615 | 528 | 528 |
| **BKT/mi** | 60 (5.7) | 700 (5.9) | 0 | 0 | 0 | 0 |
| **BKT/mi >6in** | 40 | 440 | 0 | 0 | 0 | 0 |
| **RBT/mi** | 0 | 0 | 307 (7.8) | 867 (6.6) | 0 | 0 |

| | Dayton Gulch Creek | Duncum Creek | Lake Creek | | Lick Creek | |
|---|---|---|---|---|---|---|
| RBT/mi>6in | 0 | 0 | 307 | 532 | 0 | 0 |
| SRC/mi | 0 | 0 | 0 | 0 | 0 (11.4) | 0 |
| SRC/mi>6in | 0 | 0 | 0 | 0 | 0 | 0 |
| YCT/mi | 0 | 0 | 0 | 0 | 898 (7.6) | 300 (8.5) |
| YCT/mi>6in | 0 | 0 | 0 | 0 | 825 | 300 |

**Table 14. Little Horn Project Area data continued from the table above.**

| | Lick Creek, cont. | | Little Bighorn River | | | |
|---|---|---|---|---|---|---|
| Location | T57 R89 S28 | | T56 R91 S12 SWSE | | T56 R91 S12 SWNW | |
| Elevation (ft) | 8540 | | 8275 | | 8300 | |
| Date | 30-Aug-1983 | 29-Jun-1988 | 12-Jul-1994 | 22-Jul-1997 | 28-Aug-2007 | 27-Aug-2009 |
| Sampled length (ft) | 855 | 528 | 283 | 325 | 456 | 397 |
| BKT/mi | 0 | 0 | 1611 (5.0) | 1220 (5.5) | 3451 (5.7) | 3857 (5.6) |
| BKT/mi >6in | 0 | 0 | 393 | 382 | 1494 | 1556 |
| RBT/mi | 25 (9.9) | 0 | 112 (9.3) | 0 | 0 | 0 |
| RBT/mi >6in | 25 | 0 | 112 | 0 | 0 | 0 |
| YCT/mi | 0 | 658 (7.0) | 281 (8.5) | 16 (10.3) | 1633 (5.0) | 266 (6.4) |
| YCT/mi>6in | 0 | 614 | 281 | 16 | 347 | 186 |

**Table 15. Little Horn Project Area data continued from the table above.**

| | Little Bighorn River, cont. | | Wagon Box Creek | |
|---|---|---|---|---|
| Location | T56 R91 S26 | | T57 R90 S29 | |
| Elevation (ft) | 8790 | | 6760 | |
| Date | 21-Aug-2001 | 05-Aug-2003 | 01-Aug-1973 | 10-Aug-1983 |
| Sampled length (ft) | 360 | 360 | 264 | 264 |
| BKT/mi | 557 (5.1) | 279 (7.2) | 20 (7.4) | 40 (7.1) |
| BKT/mi >6in | 264 | 205 | 20 | 20 |

| | Little Bighorn River, cont. | | Wagon Box Creek | |
|---|---|---|---|---|
| RBT/mi | 0 | 0 | 120 (8.4) | 240 (8.4) |
| RBT/mi >6in | 0 | 0 | 120 | 240 |
| YCT/mi | 73 (10.0) | 103 (5.1) | 0 | 0 |
| YCT/mi>6in | 73 | - | 0 | 0 |

**Table 16. Fish population estimates in the Rock Creek Project Area. Numbers in parenthesis represent mean length in inches.**

| | Middle Fork Rock Creek | South Fork Rock Creek | |
|---|---|---|---|
| Location | T51 R84 S10 NESW | T51 R84 S10 NESW | T51 R84 S21 SENE |
| Elevation (ft) | 7020 | 7000 | 7460 |
| Date | 13-Aug-1990 | 13-Aug-1990 | 14-Aug-1990 |
| Sampled length (ft) | 235 | 271 | 376 |
| BKT/mi | 2136 (5.7) | 7793 (6.3) | 2006 (6.0) |
| BKT/mi >6in | 1014 | 4274 | 1071 |
| RBT/mi | 0 | 39 (8.5) | 0 |
| RBT/mi>6in | 0 | 39 | 0 |

**Table 17. Fish population estimates in the Tensleep Project Area. Numbers in parenthesis represent mean length in inches. Population size estimates unavailable for 16-Jul-2009 sampling at Middle Tensleep Creek.**

| | Baby Wagon Creek | | Leigh Creek | | Middle Tensleep Creek |
|---|---|---|---|---|---|
| Location | T49 R86 S23 SE | T49 R86 S23 | T48 R87 S33 SW | T48 R87 S33 NW | T49 R86 S9 |
| Elevation (ft) | 9383 | 9400 | 5925 | 8071 | 9200 |
| Date | 24-Aug-1991 | 08-Aug-1995 | 06-Sep-1995 | 10-Aug1995 | 28-Aug-1991 |
| Sampled length (ft) | 300 | 393 | 180 | 311 | 264 |
| BKT/mi | 1440 (6.0) | 322 (5.8) | 29 (1.5) | 1003 (5.8) | 142 (7.8) |
| BKT/mi >6in | 735 | 188 | 0 | 425 | 142 |
| BNT/mi | 0 | 0 (10.3) | 645 (8.7) | 0 | 0 |

| | Baby Wagon Creek | | Leigh Creek | | Middle Tensleep Creek |
|---|---|---|---|---|---|
| BNT/mi >6in | 0 | 0 | 0 | 0 | 0 |
| RBT/mi | 0 | 0 | 968 (8.3) | 595 (5.2) | 511 (7.6) |
| RBT/mi>6in | 0 | 0 | 909 | 225 | 441 |
| SRC/mi | 0 | 0 | 88 (11.1) | 0 | 0 |
| SRC/mi >6in | 0 | 0 | 88 | 0 | 0 |

### *Threatened and Endangered Species*

There are no fish species within the analysis area listed as threatened or endangered under the Endangered Species Act. Preparation of a Biological Assessment and consultation with the U.S. Fish and Wildlife Service was not required.

### *Sensitive Species*

#### Yellowstone cutthroat trout (*Oncorhynchus clarkii bouveri*)

The analysis area falls within the identified historic range of Yellowstone cutthroat trout (YCT) distribution (Behnke 1992, Gresswell 2009, May et al. 2007).

YCT are present in nineteen streams within the project area allotments: Bear Trap Creek, Cedar Creek, Dayton Gulch, East Tensleep Creek, Gold Creek, Half Ounce Creek, Kettle Gulch, Lick Creek, Little Bighorn River, Mann Creek, Middle Tensleep Creek, North Fork West Pass Creek, Red Canyon Creek, South Fork West Pass Creek, Squaw Creek, Tensleep Creek, Wagon Box Creek, West Fork Little Bighorn River, and West Tensleep Creek.

Additional information on YCT can be found in the Fisheries Biological Evaluation found in the project record.

#### Mountain Sucker (*Catostomus platyrhynchus*)

Historic distribution of mountain sucker (MS) in the Big Horn Mountains is unknown. This species has wide distribution outside the Bighorn National Forest in lower elevation drainages. Self-sustaining populations have been identified downstream from the Forest boundary in the Paint Rock, Shell, and Tensleep drainages on the western slope and in the Tongue and Powder River drainages on the eastern slope. Mountain sucker populations on the BNF are found in the South Tongue River and Kearney Reservoir on the east side of the Big Horn Mountains. Mountain sucker are not known to be present in analysis area or project area, however they are located downstream of the Forest boundary.

Additional information on MS can be found in the Fisheries Biological Evaluation found in the project record.

**Table 18. Sensitive fish species in the analysis area (AA) (on forest only) and project area (PA)**

| | Miles of Perennial Stream | | Acres of Lake | |
|---|---|---|---|---|
| Sensitive Fish Species Present | Within AA (watersheds) | Within PA (allotments) | Within AA (watersheds) | Within PA (allotments) |
| YCT | 64 | 38 | 503 | 0 |
| MS | 0 | 0 | 0 | 0 |

### *Management Indicator Species*

#### Rainbow trout (*Oncorhynchus mykiss*)

The Bighorn National Forest selected rainbow trout (RBT) as a management indicator species (MIS) (USFS 2005). RBT fit the criteria listed for MIS under the 1982 36 CFR 219.19 (a)(1) regulations, developed to implement the NFMA of 1976. Rainbow trout are widely distributed across the Forest; they are present at some level in approximately 30% of all perennial streams and 57% of fish-bearing lakes (BNF data). Natural reproduction occurs in the streams and some lakes, but many high altitude lake populations are augmented by stocking. Approximately 81 miles (18%) of perennial streams within the project area are dominated by rainbow trout; some of these streams include: Little Bighorn River, Lake Creek, East Fork Little Goose Creek, and Dry Fork. RBT are the dominant species in 86 acres of lake (7%) within the project area and include: Bighorn Reservor (14 acres) and Cross Creek Reservoir (55 acres). Rainbow trout as MIS were assessed in the revised forest plan FEIS to which this analysis is tiered.

## Air Quality

Air pollution has the potential to impact a variety of resources on the Bighorn National Forest including visibility, water, soils, and sensitive species of flora and fauna. The Forest Service is involved in the protection of air quality through a number of laws and regulations. The 1990 Clean Air Act requires the control of particulates of size 10 micrometers in diameter and smaller. Air quality on the Forest is good and typically meets national and state air quality standards, except in the case of large wildfires, where national and state air quality standards may be temporarily and locally exceeded. Livestock grazing is unlikely to have an effect on air quality, regardless of management strategy. Therefore, air quality is not analyzed further in this report.

# *Desired Condition*

## Air Quality

The desired condition for air quality is to meet or exceed state and federal air quality standards. Air quality on the Forest is affected by other sources such as dust from road maintenance, road construction, and road use, and through smoke and soot from fires. Effective implementation of Best Management Practices (BMPs) and Forest Plan (2005) Air Guideline 1 would aid in achieving desired conditions for air quality across the Forest.

# Hydrology

## *Streams*

The desired condition for stream channels is to maintain or adjust variables, such as bankfull width, pool to riffle sequences, sinuosity, width-depth ratio, etc., so that those variables are within the expected range of variability described by Rosgen (1996), for a given stream type.

A complex interaction of streamflow, sediment, geology, and landform dictate the shape of stream channels. Stream channels form within these variables to maximize the dissipation of energy and to move water and sediment through a watershed. Each hydrologic system has developed over geologic time to effectively manage these inputs. Changes in the amount of energy in the system or water/sediment regime, whether from natural or anthropogenic causes, can disrupt the dynamic equilibrium of the hydrologic system causing stream channels to adjust in an attempt to achieve a balance between water and sediment transport. Streams adapt well to natural changes, rather than man-caused changes, because natural disturbances are typically low in frequency and localized, while anthropogenic changes are generally higher in frequency and widely distributed.

Natural processes can cause streams to move out of, or away from desired conditions, depending upon the magnitude of the event. Floods and landslides are two examples of natural processes that could occur within the analysis watersheds. Not every length of stream or acre of riparian area is expected to meet the desired conditions, and dynamically stable streams and riparian zones are expected to have areas of erosion, deposition, and undesired plants. These areas make up a small percentage of stream channels across the landscape.

Adherence to Forest Plan standards and guidelines and use of Best Management Practices (BMPs) during project implementation or permit administration would aid in achieving desired conditions for streams.

C and E stream types are typically found in wide valleys that have undergone sediment deposition. These channels have well developed floodplains, are relatively sinuous, and have a riffle-pool pattern (Rosgen 1996). These low gradient stream channels typically have low bank height/rooting depth, or bank height/bankfull stage ratios, and have a low potential for streambank erosion (Rosgen 1996). Deep-rooted riparian vegetation is crucial to bank stability in these stream types and the desired condition is to have a mixture of willow- and sedge-dominated plant communities in the riparian zone. No specific community type is preferred over another; however species that are capable of withstanding natural disturbances are desired and would minimize effects resulting from land management activities.

## *Water Quality (Issue 7)*

The desired condition for water quality is to maintain or improve water quality where beneficial uses are not being supported, and meet water quality standards defined by the State of Wyoming (WYDEQ 2007) through the reduction of point and nonpoint sources of pollution. Because most sources of impairment to water quality are from nonpoint sources, control would be achieved through the implementation of BMPs defined in the Watershed Conservation Practices Handbook (WCPH, USFS 2006, FSH 2509.25 zero code), but is not necessarily limited to these sources.

## *Water Quantity*

The desired condition for water quantity is to continue to provide water for beneficial use without adversely affecting aquatic and fisheries resources.

## Riparian Areas and Wetlands (Issue 3)

The desired condition for riparian areas is to conserve or improve the ability of these areas to absorb water, filter sediment, and sustain stream channel integrity (WCPH – USFS 2006) and provide for healthy aquatic habitats. Plant species that are indicative of streambank stability and wet or riparian areas, such as sedges, rushes, and willows, are preferred over non-native upland species such as Kentucky bluegrass and dandelion.

Where stream banks are dominated by plant communities, as defined by Winward (2000), channel morphology is controlled by vegetation which provides for bank stability. In these stream types, it is desired to have willows, where they are capable of growing, that have a mixture of age classes and heights. This diversity supports stream bank integrity against the forces of moving water during high flow events and helps to maintain desired conditions for other soil and aquatic resources, such as aquatic habitat.

The desired condition for wetlands is to sustain the ecological function of these unique areas. This can be achieved by maintaining long-term ground cover, soil structure, water budgets, and hydrologic flow patterns (WCPH – USFS 2006; 12.4 Management Measure 6). Rare wetlands such as fens and springs should be given extra attention to ensure they are not disrupted, as these wetlands typically cannot be replaced in-kind (WCPH – USFS 2006; 12.4 Management Measure 6, Design Criteria 1.e.). The effective implementation of BMPs would aid in achieving desired wetland conditions.

## Soils (Issue 3)

"Activity Area" definition change was made after Tommy J's and Ratner's comments.

The desired condition for soils is to maintain the long-term quality of soils and to decrease the potential for erosion, compaction, and mass movements that may result from land management activities. Soil quality is defined as the natural capacity of a specific soil, as determined by its inherent physical, chemical, and biological characteristics, to perform its biologic, hydrologic, and ecologic functions (WCPH – USFS 2006). Additionally, the WCPH gives direction to: "Manage land treatments to limit the sum of severely burned soil and detrimentally compacted, eroded and displaced soil to no more than 15% of any activity area." The WCPH (FSH 2509.25) defines Activity Area as: "*an area of land impacted by a management activity ranging from a few acres to an entire watershed depending on the type of monitoring being conducted. It is commonly a timber sale cutting unit, a prescribed fire burn unit or an allotment pasture*." The 15% limit applies to all natural and human disturbances that may impact soil structure, organic matter and nutrients in areas allocated for vegetation production.

Of the numerous soil associations across the forest, some are more susceptible to impacts from livestock grazing, prescribed fire, vegetation treatments to aspen, sagebrush, and conifer, and associated activities due to physical limitations. These soils are naturally prone to erosion and mass movements, because of their relatively higher clay content compared to other soils on the forest. The desired condition for these soil types is to reduce the potential for excessive erosion or catastrophic mass movements beyond the natural range of variability.

In the EIS, please replace the original bullets in the section with the new bullets highlighted in blue text. This change was made based on Tommy John's comments.

- **Cryaquoll Association (16) -** Many areas of this unit have a water table at or near the surface or are wet for significant periods of time, making them susceptible to compaction. Frequent flooding and poor drainage are major limitations for many uses in this soil type (Nesser 1986).

- **Leavitt-Passcreek Association (24) -** The moderate to severe hazard of water erosion on the Leavitt soil requires careful grazing management on this unit (Nesser 1986).
- **Owen Creek-Waybe Association (30)** – This soil has frequent mass movements and a high shrink-swell potential. The major limitation for producing forage is droughtiness of the Waybe soil. And the moderate to severe hazard of water erosion on the Waybe soil necessitates careful grazing management on this unit (Nesser 1986).
- **Tolman-Beenom-Carbol (42)** – The major limitation for producing forage on this unit is droughtiness of the Tolman and Carbol variant soils. The moderate to severe hazard of water erosion on the Beenom and Carbol variants requires careful grazing management (Nesser 1986).
- **Nesda (95)** – These soils, as identified by the NRCS soil series database (2009), are subject to frequent flooding as they are located near floodplains and stream terraces. This makes them susceptible to compaction by livestock grazing.
- **Tolman-Beeno-Beenom (99) –** These soils are sensitive to livestock grazing because the Beenom variant has a moderate to severe hazard of water erosion (Nesser 1986).

If the desired condition for soils is not being met, soil conditions need to be improved through restoration, if possible, recognizing that some soil impacts are long-term and may be difficult to actively restore, therefore passive restoration may be more appropriate. Effective administration of projects and permits would reduce the potential for major negative impacts to soil resources through the implementation of Best Management Practices (BMPs), such as proper road location and layout, utilization standards for livestock grazing, and timing limitations. Specific design criteria that meet this objective can be found in the WCPH review in Appendix A.

### Fisheries (Issue 6)

The desired condition for fisheries and other aquatic organisms is to maintain self-reproducing populations of native and desired non-native aquatic species through the management of aquatic habitats. Because fisheries resources are directly affected by hydrology and soil conditions, this is achieved by meeting desired conditions for these physical resources. If the desired condition is not being met, the watershed condition should be improved or aquatic habitat restored using the best available methods. The ecological function of uplands and riparian areas drive the ecological conditions that ultimately affect aquatic habitats. Managing for healthy watershed conditions would help to achieve the desired condition for aquatic habitats and give aquatic organisms the best chance to persist.

It may also be desirable to expand the distribution of the native Yellowstone cutthroat trout (YCT) in many cases, through the removal of non-native species to expand the distribution of YCT. All population management for fish species would be conducted under the authority of the Wyoming Game and Fish Department.

## *Monitoring Locations*

Long-term stream monitoring locations were established on the Bighorn National Forest as part of the Revised Forest Plan (USFS 2005) monitoring direction for aquatic resources. Long-term monitoring sites were developed to determine aquatic baseline conditions and determine the effects of land management activities on aquatic resources at a forest-wide scale. The long-term monitoring sites that fall within the Big 6 analysis area are discussed below. Because these sites are part of a forest-wide monitoring effort, it is not necessary to designate them as required monitoring in this NEPA decision.

Additional monitoring locations were developed during interdisciplinary team meetings and during field site visits. These locations include 50-width measurements and photo points to identify existing and desired conditions of aquatic and soil resources. These monitoring locations are discussed below and are part of the monitoring for Big 6 NEPA decision.

Furthermore, a peer-reviewed study in the Rock Creek project area (Nowakowski and Wohl 2008) is discussed below to identify existing conditions and determine potential effects to aquatic resources from livestock grazing. Because the stream locations analyzed in this study were designed to address instream wood loading, they are not designated as required monitoring in the Big 6 NEPA decision.

## *Goose Creek Project Area*

### Antler Creek

A 50-widths location was established on Antler Creek in 2009, to determine a mean width/depth ratio. The site is located in the meadow to the south of forest road 406. Fifty bankfull widths and bankfull depths can be measured at the same stream location across multiple years to determine if there is a change over time. At this site, the width/depth ratio is 6.1, which is a stable dimension for this channel type (Rosgen “E” channel). The desired condition for a Rosgen “E” channel type is to have an overall width/depth ratio less than 12. Therefore, Antler Creek currently has a suitable width/depth ratio. Furthermore, the site visit on July 23, 2009 indicated that stream banks had vigorous riparian vegetation, and previously destabilized stream banks and point bars were re-vegetating and the stream was narrowing appropriately. The desired condition for Antler Creek is to maintain a width/depth ratio less than 12 at this location. The table below gives a summary of current and desired conditions.

### Babione Creek

A 50-widths location was established on Babione Creek in 2009, in the meadow upstream (southwest) from where forest road 299 crosses the creek. Fifty bankfull widths and bankfull depths can be measured at the same stream location across multiple years to determine if there is a change in width/depth ratio over time. At this location, the Rosgen stream type is an “E” channel and the width/depth ratio is 5.44. This corresponds appropriately, as the width/depth ratio for this channel type should be less than 12. The site visit to Babione Creek on July 27, 2009 also identified vigorous riparian vegetation and stable banks. The desired condition for Babione Creek is to maintain a width/depth ratio less than 12 at this location. The table below gives a summary of current and desired conditions.

### Buck Creek

The desired condition for Buck Creek, above the confluence with Walker Creek, is to maintain or increase channel/riparian condition (the ability to absorb water, filter sediment, and sustain stream channel integrity (WCPH – USFS 2006) and provide for healthy aquatic habitats). This section of Buck Creek flows through a gently sloped meadow. A mid-summer field visit in 2007 revealed evidence that past grazing activity is currently recovering. Bare soil is present on the upland meadow adjacent to the stream, but riparian vegetation is dense and completely covers the channel banks.

A photo point was established in the summer of 2008, and retaken in 2009, to visually monitor the channel banks and riparian area of Buck Creek. The photo should be retaken in 2010, and will thereafter have a longer monitoring frequency that will depend on the observed changes. The photo is taken by the forest archaeologist, who will be assessing cultural resources in the Buck Creek area, and therefore will not duplicate our efforts. The table below gives a summary of current and desired conditions.

### East Fork Big Goose Creek

The desired condition for stream channels is to maintain or adjust variables, such as bankfull width, pool to riffle sequences, sinuosity, width-depth ratio, etc., so that those variables are within the expected range of variability described by Rosgen (1996), for a given stream type. A long-term monitoring site was established on East Fork Big Goose Creek upstream from Park Reservoir in the summer of 2006, and resurveyed in 2009. A longitudinal profile, three cross-sections, 50 average widths/depths, a pebble count, and a greenline were measured. The following table provides a summary of current and desired conditions.

This reach flows through a willow-dominated, flat valley bottom confined by Heidley Park to the west. It is currently a "C" channel, with high sinuosity (1.65), high width:depth ratios, and a gentle slope (0.5%). The coarse gravel substrate further classifies the present channel as a C4 Rosgen-type channel. The table below gives a summary of current and desired conditions.

### Quartz Creek

In the summer of 2007, a long-term monitoring site was established on Quartz Creek, upstream from Big Bend. A longitudinal profile, three cross-sections, 50 average widths/depths, a pebble count, and a greenline were measured. The site was resurveyed in 2009. The table below provides a summary of current and desired conditions.

This reach flows through Walker Prairie, an upland meadow bound by a forested hillslope to the west. The stream is a "C" type channel, with high sinuosity (1.77), high width:depth ratios, and a gentle slope (0.03%). The coarse gravel substrate further classifies the present channel as a C4 Rosgen-type channel. The table below gives a summary of current and desired conditions.

### Walker Creek

The desired condition for the headwaters of Walker Creek is to maintain or increase riparian condition (the ability to absorb water, filter sediment, and sustain stream channel integrity (WCPH – USFS 2006) and provide for healthy aquatic habitats). The headwaters consist of a spring emerging in a grassy swale with no defined channel. A mid-summer field visit in 2007 revealed evidence that past grazing activity is currently recovering. Hummocking is evident but is limited in area, comprising the swale bottom but not the entire riparian extent. Vegetation is dense and bare soil is not visible, indicating soil has not recently been disturbed. The table below gives a summary of current and desired conditions.

Historic livestock grazing practices contributed heavily to the existing conditions. Photographs taken in the early 1900's, in comparison with photos taken in the same location 75 years later (Re-discovering the Big Horns, 1998, p. 41), illustrate that although grazing management has improved since the early 1900's, it takes quite some time for hardened soil hummocks to recover. While it is difficult to determine when hummocking occurred in the headwaters of Walker Creek, the hummocks may be a remnant of past grazing activity. Recent hoof prints and soil disturbances are a sign of current livestock grazing, but the current level of use does not appear to match the amount or apparent age of hummocking. Hummocks in this area were revegetated with sedges and grasses.

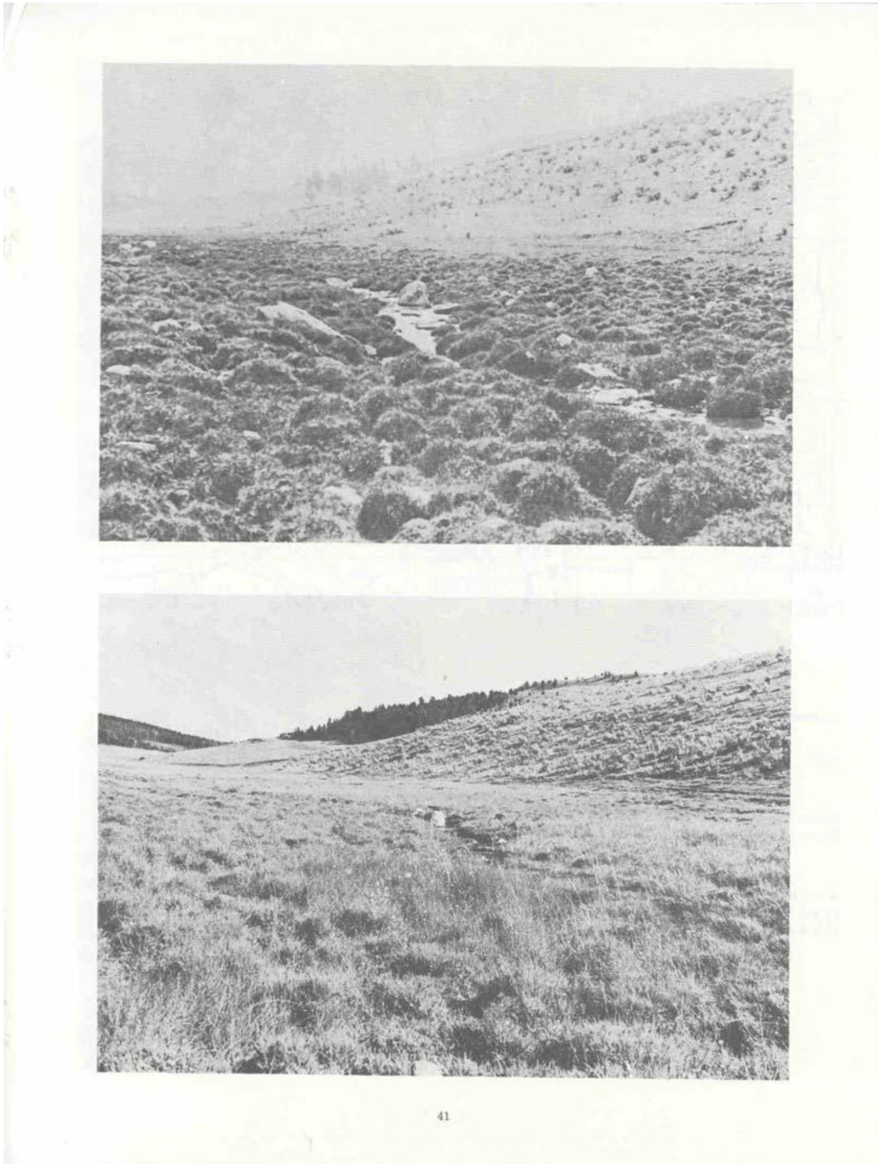

**Figure 3. Photos showing recovery time for soil hummocking on the Bighorn National Forest, Paintrock Creek watershed. The upper photo was taken by Professor Jack in 1900. The lower photo was re-taken in 1975. This figure is copied from "Re-discovering the Big Horns 1976".**

Nonetheless, it is important to monitor soil hummocks to determine effects of livestock grazing on hummocking. A photo point was established in the summer of 2008, and retaken in 2009, to visually monitor this area. The photo should be retaken in 2010, and will thereafter have a longer monitoring frequency that will depend on the observed changes. The photo is taken by the forest archaeologist, who will be assessing cultural resources in the Walker Creek area, and therefore will not duplicate our efforts.

**Table 19. Current and desired conditions at monitoring locations in the Goose Creek project area**

| Location | Current Condition | Desired Condition | Approximate Monitoring Frequency |
|---|---|---|---|
| **Antler Creek** | w:d ratio = 6.1 | w:d ratio less than 12 | as needed |
| **Babione Creek** | w:d ratio = 5.44 | w:d ratio less than 12 | as needed |
| **Buck Creek** | bare soil in upland, dense vegetation in riparian | maintain or increase channel/riparian condition | every year for first 3 years, 5 years thereafter |
| **East Fork Big Goose Creek** (Park Reservoir) 2009 | 50 widths/depths: mean width = 33.10 ft mean depth = 1.85 ft mean w:d ratio = 16.82 pebble count: $D_{50}$ = 50.0 mm $D_{84}$ = 123.6 mm successional status: mid seral stability rating: moderate | 50 widths/depths: mean width = maintain mean depth = maintain mean w:d ratio = maintain pebble count: $D_{50}$ = appropriate for channel type and geology $D_{84}$ = appropriate for channel type and geology successional status: maintain, forest plan direction is for mid to late seral stability rating: maintain or increase | 5 years |
| **Quartz Creek** (Big Bend) 2009 | 50 widths/depths: mean width = 17.08 ft mean depth = 0.96 ft mean w:d ratio = 12.47 pebble count: $D_{50}$ = 46.7 mm $D_{84}$ = 86.7 mm successional status: late seral stability rating: moderate | 50 widths/depths: mean width = decrease mean depth = increase mean w:d ratio = decrease pebble count: $D_{50}$ = appropriate for channel type and geology $D_{84}$ = appropriate for channel type and geology successional status: maintain, forest plan direction is for mid to late seral stability rating: maintain or increase | 5 years |
| **Walker Creek** | Long-standing hummocks in swale bottom, dense vegetation throughout | maintain or increase riparian condition | every year for first 3 years, 5 years thereafter |

## *Little Horn Project Area*

### Little Bighorn River

In the summer of 2006, a long-term monitoring site was established on the Little Bighorn River, between the confluences of Half Ounce Creek and Dayton Gulch. A longitudinal profile, three cross-sections, 50 average widths/depths, a pebble count, and a greenline were measured. The site was resurveyed in 2009. The table below provides a summary of current and desired conditions.

**Table 20. Current and desired conditions at monitoring locations in the Little Horn project area**

| Location | Current Condition | Desired Condition | Approximate Monitoring Frequency |
|---|---|---|---|
| **Little Bighorn River** (Dayton Gulch) 2006, 2009 | 50 widths/depths: mean width = 20.32 ft mean depth = 1.27 ft mean w:d ratio = 10.17 pebble count: $D_{50}$ = 37.0 mm $D_{84}$ = 128.0 mm successional status: PNC stability rating: high | 50 widths/depths: mean width = maintain mean depth = maintain mean w:d ratio = maintain pebble count: $D_{50}$ = appropriate for channel type and geology $D_{84}$ = appropriate for channel type and geology successional status: forest plan direction is for mid to late seral stability rating: maintain or increase | 5 years |

## *Rock Creek Project Area*

Nowakowski and Wohl (2008) surveyed six randomly-selected stream reaches in the North Rock Creek watershed during the summer of 2006 to identify instream wood loading in a watershed with minimal forest disturbance. These surveys identify existing conditions in the Rock Creek project area and suggest how streams within the project area may respond to livestock grazing.

A longitudinal profile, riffle cross section, and pebble count were measured in each reach. Instream wood dimensions were estimated using low-level aerial photographs and used to calculate wood loading (volume of wood in the bankfull area divided by the bankfull channel area). Forest stand density was evaluated at the cross section of each reach by estimating basal area ($m^2$/ha) for trees adjacent to the channel (Nowakowski and Wohl 2008). The following table provides a summary of the characteristics measured in each reach.

**Table 21. Streams surveyed in the Rock Creek project area.**

| Stream site | slope (%) | width (m) | depth (m) | w/d | $A_{xs}$ ($m^2$) | $D_{84}$ (mm) | BA ($m^2$/ha) | DA ($km^2$) | $W_{load}$ ($m^3$/ha) |
|---|---|---|---|---|---|---|---|---|---|
| Balm of Gilead 354 | 4.4 | 2.8 | 0.6 | 4.7 | 1.71 | 170 | 13.8 | 9.9 | 175 |
| Middle Rock 430 | 5.6 | 3.1 | 0.7 | 4.4 | 2.08 | 232 | 5.7 | 25.1 | 16 |
| South Rock 92 | 2.5 | 9.4 | 1.0 | 9.4 | 8.88 | 318 | 1.1 | 84.7 | 21 |
| South Rock 99 | 2.3 | 6.9 | 0.5 | 13.8 | 3.31 | 153 | 11.5 | 80.8 | 137 |
| South Rock 115 | 4.8 | 6.1 | 0.6 | 10.2 | 3.90 | 349 | 17.2 | 33.0 | 133 |
| South Rock 123 | 4.9 | 7.2 | 0.7 | 10.3 | 5.18 | 212 | 9.2 | 20.8 | 24 |

$A_{xs}$ = channel cross-sectional area; $D_{84}$ = the grain size for which 84% of the distribution is finer; BA = tree basal area in the riparian zone; DA = drainage area; $W_{load}$ = volume of wood in the bankfull area divided by the bankfull channel area

The streams surveyed in the North Rock Creek watershed have moderate to high slopes (2.3 - 5.6%) and large substrate (large cobble to small boulder; 153 - 349 mm). In general, large substrate may reduce the impacts from livestock grazing, as cobbles and boulders protect stream banks and the channel bottom; see figure below for an example of particle size distribution in the study area. Given that different channel types have different responses to livestock grazing (George 1996, Rosgen 1996), the channel variables measured in this study suggest that these streams will have a low vulnerability to disturbance by livestock.

**Figure 4. Example of particle size distribution in the North Rock Creek Watershed. D84 = 212 mm. South Rock Creek, site 123. Photo taken on 07/19/2006.**

The stream reaches surveyed in this study contain a high volume of instream wood (average = 68 $m^3$/ha), when compared to a watershed with similar geology, precipitation, and elevation on the Bighorn National Forest (average = 21 $m^3$/ha, Upper Tongue watershed) (Nowakowski and Wohl 2008). See figure below for an example of instream wood within the study area. Studies have shown that wood plays an essential role in the function of stream morphology and in the development of aquatic ecosystems in forested catchments (Keller and Swanson 1979, Piegay and Gurnell 1997). Instream wood contributes to channel stability, aquatic habitat complexity, and also protects the channel bed and banks by restricting access to the channel.

Forest stand density measurements at the six stream reaches identify that mature trees are growing in the riparian areas of the North Rock Creek watershed; basal areas range from 1.1 – 17.2 $m^2$/ha. Healthy riparian areas promote proper stream hydrologic function and also have a higher potential to recruit wood into the channel. In addition, forested riparian zones generally do not support vegetation favorable for livestock consumption.

**Figure 5. Example of instream wood distribution in the North Rock Creek Watershed. Wload = 175m3/ha. Balm of Gilead Creek, site 354. Photo taken on 08/01/2006.**

In summary, the six streams analyzed by Nowakowski and Wohl (2008) suggest that channels in the North Rock Creek watershed, the northern portion of the Rock Creek project area, have a relatively low sensitivity to livestock grazing. The stream sections surveyed have moderate to high slopes, cobble to boulder-sized particle distributions, high volumes of instream wood, and have forested riparian areas.

## *Tensleep Project Area*

### Childs Creek

A 50-widths location was established on Childs Creek in September 2009, to determine a mean width/depth ratio. The site is located downstream from the crossing with road 436 (Sand Draw). The width/depth ratio at this site is 2.74, a stable dimension for this channel type (Rosgen “G” channel). The desired condition for a Rosgen “G” channel type is to have an overall width/depth ratio less than 12. Therefore, Childs Creek has a suitable width/depth ratio in its current condition. In addition, the site visit on September 18, 2009 identified good stream bank vegetation and bank stability, an indicator that width/depth ratio will be maintained. The table below gives a summary of current and desired conditions.

### East Tensleep Creek

A long-term monitoring location was established on East Tensleep Creek, between the confluences of Baby Wagon Creek and Garnet Creek, in the summer of 2005. A longitudinal profile, pebble count, three cross-sections, 50 widths/depths, and a greenline were measured. This information provides baseline data for future surveys, to identify changes to geomorphological conditions as a result of land-use activities and/or natural events. The table below gives a summary of current and desired conditions.

### Leigh Creek

A long-term stream survey site was established on Leigh Creek in 2007. The reach is located in an open meadow upstream from Leigh Canyon, and includes a longitudinal profile, four cross-sections, 50 widths/depths, and a greenline survey. The table below provides a summary of current and desired conditions. The table below gives a summary of current and desired conditions.

### Middle Tensleep Creek

In the summer of 2006, a long-term monitoring site was established on Middle Tensleep Creek, near Deer Park. A longitudinal profile, three cross-sections, 50 average widths/depths, a pebble count, and a greenline were measured. The table below provides a summary of current and desired conditions.

### Teepee Creek

A 50-widths location was established on Teepee Creek in July 2009, to determine a mean width/depth ratio. This site is located downstream from the cow camp in the open meadow. Fifty bankfull widths and bankfull depths can be measured at the same stream location across multiple years to determine if there is a change over time. At this site, the width/depth ratio is 3.16, which is a stable dimension for this channel type (Rosgen “E” channel). The desired condition for a Rosgen “E” channel type is to have an overall width/depth ratio less than 12. Therefore, Teepee Creek has a suitable width/depth ratio in its current condition. Furthermore, the site visit on July 27, 2009 identified Teepee Creek as extremely well vegetated, with stable stream banks, and had no signs of recent soil compaction or displacement. The desired condition for Teepee Creek is to maintain a width/depth ratio less than 12 at this location. The table below gives a summary of current and desired conditions.

**Table 22. Current and desired conditions at monitoring locations in the Tensleep project area**

| Location | Current Condition | Desired Condition | Approximate Monitoring Frequency |
|---|---|---|---|
| **Childs Creek** | w:d ratio = 2.74 | w:d ratio less than 12 | as needed |
| **East Tensleep Creek** (Meadow) 2006 | 50 widths/depths:<br>mean width = 29.41 ft<br>mean depth = 2.50 ft<br>mean w:d ratio = 10.35<br>pebble count:<br>$D_{50}$ = 18.8 mm<br>$D_{84}$ = 51.6 mm<br>successional status: mid seral<br>stability rating: poor | 50 widths/depths:<br>mean width = maintain<br>mean depth = maintain<br>mean w:d ratio = maintain<br>pebble count:<br>$D_{50}$ = appropriate for channel type and geology<br>$D_{84}$ = appropriate for channel type and geology<br>successional status: maintain, forest plan direction is for mid to late seral<br>stability rating: increase | 5 years |
| **Leigh Creek** (Bar) 2007 | 50 widths/depths:<br>mean width =13.84 ft<br>mean depth = 2.12 ft<br>mean w:d ratio = 10.79<br>pebble count:<br>$D_{50}$ = 48.5 mm<br>$D_{84}$ = 119.9 mm<br>successional status: mid seral<br>stability rating: moderate | 50 widths/depths:<br>mean width = maintain<br>mean depth = maintain<br>mean w:d ratio = maintain<br>pebble count:<br>$D_{50}$ = appropriate for channel type and geology<br>$D_{84}$ = appropriate for channel type and geology<br>successional status: maintain, forest plan direction is for mid to late seral<br>stability rating: maintain or increase | 5 years |
| **Middle Tensleep Creek** (Cub Park) 2006 | 50 widths/depths:<br>mean width = 27.22 ft<br>mean depth = 1.23 ft<br>mean w:d ratio = 12.63<br>pebble count:<br>$D_{50}$ = 24.3 mm<br>$D_{84}$ = 43.2 mm<br>successional status: mid seral<br>stability rating: moderate | 50 widths/depths:<br>mean width = maintain<br>mean depth = maintain<br>mean w:d ratio = maintain<br>pebble count:<br>$D_{50}$ = appropriate for channel type and geology<br>$D_{84}$ = appropriate for channel type and geology<br>successional status: maintain, forest plan direction is for mid to late seral<br>stability rating: maintain or increase | 5 years |
| **Teepee Creek** | w:d ratio = 3.16 | w:d ratio less than 12 | as needed |

# Environmental Consequences

## *Methodology*

Effects analysis was conducted for each alternative following the method below:

1. Review actions associated with the alternatives
2. Select a single resource area: hydrology, soils, or fisheries
3. Assume all applicable BMP's are met (Appendix A)
4. Review the influence, response, causes, and impacts reported in Belsky et al. (1999) for the selected resource (Belsky et al. is summarized in the Review of Potential Effects of Livestock Grazing section below)
5. Determine the linkages between the resource and step four

6. Determine if the linkage was determined to have negative, positive, or no effect to the resource
7. Repeat steps 2 through 6 for each resource
8. Repeat steps 1 through 7 for each alternative
9. Group and summarize factors common to all action alternatives
10. Discuss direct and indirect effects specific to each alternative
11. Discuss cumulative effects specific to each alternative

## *Spatial and Temporal Context for Effects Analysis*

The spatial boundaries for hydrology, soils, and fisheries effects analysis are lands within the analysis area 6th-level watersheds. Although the alternatives affect these resources only within project area allotment boundaries, a clearer picture of soil and watershed condition is obtained by looking at the watershed scale.

To clearly analyze the effects of livestock grazing and prescribed fire on hydrology, soil, and fisheries resources, it is necessary to define timeframes. Because fishery resources are directly affected by hydrology and soil conditions (water quality, infiltration and runoff, etc.), the effects timeframes are specifically defined for fisheries resources, to address any lag time that may exist between livestock effects to hydrology or soils, and subsequently to fisheries. The following definitions apply to direct, indirect, and cumulative effects analysis within this document.

- Short-term effects refer to those occurring within, or lasting for 1 to 2 generations of fish (5 to 10 years). Rieman and McIntyre (1993) and the U.S. Fish and Wildlife Service matrix of diagnostics/pathways of indicators (USFWS 1998) use this definition.
- Long-term effects refer to those occurring after or lasting greater than 10 years. Rieman and Myers (1997) found detection of trend in bull trout populations often required greater than 10 years of data.

Based on the research found within the three citations above, their use in numerous biological analyses and what is known about the life history of YCT, these definitions are applicable to effects analysis for this project.

### Connected Actions, Past, Present, and Foreseeable Activities Relevant to Cumulative Effects Analysis

The table of past, present, and reasonable foreseeable actions in the project record was used to determine actions relevant to cumulative effects analysis for hydrology, fisheries, and soil resources.

Activities considered relevant to hydrology, soils, and fisheries resources include: domestic livestock grazing, timber harvest and precommercial/commercial thinning, fire suppression, fuels reduction, wildland and prescribed fire, dispersed recreation and motorized trail use, trail maintenance, fisheries habitat projects, flow augmentation for irrigation, Hunt Mountain motorized travel plan, Hunter trailhead/campground relocation, and a water conveyance special use permit. These activities have the potential to affect hydrology, soil, and fisheries resources through soil erosion and compaction, increased sedimentation to water bodies, and possible effects to fish habitat. These potential effects are addressed in the following table and are discussed in more detail below.

Activities not considered relevant to hydrology, soils, and fisheries resources include: aspen regeneration and meadow conifer encroachment, forest insects and disease, noxious weed treatment, recreation special use permits, outfitter/guide activities, Medicine Wheel National Historic Landmark, bighorn sheep reintroduction, Cody BLM land use plan, Bud Love big game winter range management, private land inclusion, and the Big Horn sage grouse conservation plan. These activities are unlikely to affect the resources analyzed in this report, or have any measureable changes to hydrology, soils, and fisheries resources.

**Table 23. Past, present, and foreseeable activities that have the potential to effect soil, water quality, and fisheries resources. The activities marked with "none" for all three resources were not analyzed further.**

| Activity | Potential Effects to Resource | | |
|---|---|---|---|
| | Soil | Water Quality | Fisheries |
| Livestock grazing, 1906 to present | compaction, erosion | bacteria, sedimentation | sedimentation, habitat alteration |
| Timber sales (1978 to present), precommercial/commercial thinning (1980s to present), fuels reduction | compaction, erosion | sedimentation, pollutants | sedimentation, temperature increase |
| Fire suppression | compaction, erosion | sedimentation | sedimentation |
| Wildfire [1897 (Copman's Tomb) to 2007 (Bone Creek, Long Park, Bear Creek, Little Goose)] | erosion | sedimentation, nutrient availability | sedimentation |
| Prescribed fire | none | none | none |
| Recreation (dispersed camping, motorized trail use) | erosion | sedimentation, pollutants | sedimentation |
| Trail maintenance | none | none | none |
| Fish habitat projects | streambank erosion | sedimentation | sedimentation, habitat alteration |
| Stream flow augmentation for irrigation (Rapid Creek, French Creek) | none | sedimentation | sedimentation, habitat alteration |
| Hunt Mountain Travel Management Decision, 2007 | none | none | none |
| Hunter trailhead/campground relocation, Battle Park trailhead construction | none | none | none |
| Water conveyance special use permit | none | reduced water quantity | reduced water quantity |

- "None" indicates the activity would not effect, or no longer effects, the given resource

**Livestock grazing:** Domestic livestock grazing has occurred within the analysis area for over 100 years. Historic livestock grazing practices contributed to existing conditions seen today. Based on the intensity and extent of past effects of livestock grazing it was determined this action is relevant to cumulative effects analysis.

**Timber harvest:** In this cumulative effects analysis, timber harvest includes timber sales, precommercial thinning, commercial thinning, and fuels reduction. Timber harvest has known effects to aquatic and soil resources. If a sufficient portion of a watershed is harvested, water yield, sedimentation, and water temperature may increase, soil may compact and erode, and fish habitat may be affected as a result. Over time, timber harvest areas revegetate, which stabilizes soils and reduces the potential for erosion. Harvest areas that have undergone these recovery processes have no measureable incremental effects that could add cumulatively. Recent timber harvest activities include design criteria direction from the WCPH (USFS 2006), which minimizes the risk of affecting soils and aquatic resources. However, recent harvest may add cumulatively and is therefore relevant to cumulative effects analysis.

**Fire suppression:** Fire suppression activities have increased the risk for large, stand-replacing fires. If a fire of this type occurred within the analysis area it could produce measurable effects to soil and aquatic resources. Additionally, fire suppression activities may affect soil and water quality as access roads and fire lines are constructed mechanically. This activity is relevant to cumulative effects analysis.

**Past wildfire:** Historic wildfires within the analysis area have revegetated to the point where no measurable effects are contributed to the watershed. Recent wildfires, such as the 2007 Bone Creek Fire, have the potential to contribute to soil erosion and sediment delivery to streams. Therefore, this action is relevant to cumulative effects analysis.

**Prescribed Fire:** Prescribed fire is conducted in a manner, which minimizes fire residence time on soils and minimizes effects on hydrologic resources. This action is not relevant to cumulative effects analysis.

**Dispersed camping and motorized trail use:** Recreation activities have increased over the past two decades and are expected to grow in the analysis area. Such activities compact and erode soils, increase overland flow, and provide a source of sediment into streams. This activity is relevant to cumulative effects analysis.

**Trail maintenance:** Trail maintenance provides a long-term benefit to aquatic and soil resources, as trail areas with erosion and sedimentation effects are repaired. This action is not relevant to cumulative effects analysis.

**Fish habitat projects:** Instream log and gabion structures were installed perpendicular to stream flow to create pools for fish habitat. Most structures were installed between 1970 and 1990. These structures changed the natural fluvial geomorphology of streams within the analysis area. When structures are placed perpendicular to stream flow, the natural channel geometry adjusts to regain equilibrium. In most cases on the Bighorn National Forest, this has resulted in a decrease in channel sinuosity. The decreased sinuosity creates a number of meander-bend cutoffs, which erode stream banks and increase sediment delivery into the channel; therefore, this action is relevant to cumulative effects analysis.

**Stream flow augmentation for irrigation**: Irrigation water is both conveyed into and diverted away from streams on the forest. Augmented flows increase stream power, and have the potential to erode stream banks and alter fish habitat. Because the Wyoming Department of Environmental Quality found French Creek (a stream with augmented irrigation flows in the project area) to meet its aquatic life uses, this action will not be analyzed cumulatively in terms of fish populations and fish habitat (WYDEQ 2008). However, this action is relevant to cumulative effects in terms of increased sedimentation, and will be discussed further.

**Hunt Mountain Travel Management Decision:** This decision restricted summer motorized travel to designated routes, identified the motorized travel system, and closed some system and non-system trails and roads. It is anticipated that these actions could reduce soil erosion and associated impacts to water bodies. Therefore, this action is not relevant to cumulative effects analysis.

**Hunter trailhead/campground relocation and Battle Park trailhead construction:** The Battle Park trailhead facility was built in 2004. The trailhead serves as a popular area for users to access the Cloud Peak Wilderness. Improvements in the Hunter trailhead/campground area should remove existing disturbances outside of the riparian area. Therefore, this action is not considered in cumulative effects analysis.

**Water conveyance special use permit:** A livestock pipeline draws water from Leigh Creek, crosses the forest, and delivers water for private livestock use. This action reduces the volume of flow in Leigh Creek, and may alter aquatic habitat. This action is relevant to cumulative effects analysis in terms of fish habitat.

## Review of Potential Effects from Livestock Grazing

This section illustrates the range of direct and indirect effects considered during effects analysis. The effects reviewed are some of the most commonly documented resulting from livestock grazing. This is not a comprehensive review of effects of livestock grazing on soil and aquatic resources. Please refer to Belsky et al. (1999), Fleischner (1994), Kauffman and Krueger (1984), and Platts (1990, 1991) for reviews that are more thorough. This review is not effects analysis; analysis of effects occurs in the sections below.

Riparian areas are normally the most ecologically diverse and productive terrestrial habitats (Naiman et al. 1993) and favored environments for livestock and other animals (Kauffman and Krueger 1984, Kovalchik and Elmore 1992). These areas provide water, shade, flatter terrain, abundant and variable forage, hiding cover and softer soils (Kovalchik and Elmore 1992, Kauffman and Krueger 1984). The effects livestock grazing has on riparian areas are well documented and reviewed by many authors including Belsky et al. (1999), Fleischner (1994), Platts (1991) and Kauffman and Krueger (1984).

In general, livestock grazing affect five components of riparian zones, streamside vegetation, channel morphology, quality of water, stream flow pattern, and soil structure of streambanks (Belsky et al. 1999, Fleischner 1994, Kauffman and Krueger 1984). Vegetation is removed or altered during grazing or from trampling. Channel morphology is altered due to trampling of banks, removal of vegetation and increased erosion. Changes in the water column result from erosion, loss of vegetation, trampling of banks and deposit of urine and feces (Belsky et al. 1999, Fleischner 1994, Kauffman and Krueger 1984). Streambank soils are altered due to trampling, increased compaction and increased erosion (Belsky et al. 1999, Clary 1995, Clary 1999, Clary and Kinney 2002, Clary et al. 1996, Fleischner 1994, Kauffman and Krueger 1984).

### Streamside Vegetation (Issue 3)

Livestock grazing affects vegetation via browsing and physical damage. Riparian zones provide abundant palatable forage (Kovalchik and Elmore 1992, Platts and Nelson 1989). A review of literature shows a general acceptance that riparian areas produce a high percentage of forage from a small percentage of land area.

Riparian vegetation provides many watershed functions including sediment and nutrient filtration, and resistance to erosion. Abouguendia (2001) suggests the ability of a riparian area to effectively remove sediments, nutrients, and chemicals from flowing water relies on environmental conditions, physical and geographic features, and vegetation characteristics. Riparian vegetation reduces water velocity and decreases potential soil erosion (Kauffman and Krueger 1984).

Woody species with diverse age structure where species are part of the natural system are important for pool formation, stability, shade, insulation, energy dissipation, aquatic food input, and habitat.

Kovalchik and Elmore (1992) reported cattle began to use current annual growth on willows when riparian forage use reached 45% of total available forage (4 to 6 in stubble height) during mid- to late season livestock grazing. They noted use of woody species increased again at 65% (2 to 4 in stubble height) use, and cattle eat all the willow they can at 85% utilization. Excessive livestock grazing may eliminate a willow stand within 30 years. The presence of dead and dying willows suggest over use (Kovalchik and Elmore 1992).

Clary and Webster (1989) suggested the reduction of shrubby vegetation in the riparian areas of the Sawtooth National Forest was a result of grazing of young plants as opposed to physical damage by livestock. Severe overgrazing is usually detrimental to willow communities (Kauffman and Krueger 1984).

Grazing systems designed for uplands should be used only where negative effects on willows can be mitigated by strict enforcement of riparian forage use to prevent the switch from grazing to browsing. Otherwise, use will result in downward condition trends in willow dominated plant associations (Kovalchik and Elmore 1992).

Utilization of woody species by wild ungulates must also be considered when managing woody vegetation within a riparian zone. Monitoring on the Bighorn National Forest shows willow utilization by deer, elk, and moose can be very high. This use combined with livestock grazing may lead to over use and eventually eliminate willows with in a reach of stream.

### *Channel Morphology*

Livestock grazing can affect channel morphology by sediment deposition, alteration of substrate, disruption of the relation of pools to riffles, and widening of the channel. Platts (1981) found channel width to be four times greater in areas heavily grazed by sheep compared to lightly grazed areas. Kauffman et al. (1983) found differences in bank erosion rates between season-long and ungrazed stream reaches. This result can be interpreted as the heavily grazed section having wider stream channel than the ungrazed section. Overton et al. (1994) reported a width to depth ratio 113% greater in grazed versus ungrazed sections of Silver King Creek, California. Platts (1991) reported a reduction in stream width of 10 to 400 percent following removal of livestock grazing. Clary (1999) found decreases in stream width varied inversely with livestock grazing intensity.

Streambank stability is determined by the soil's ability to resist displacement and by vegetative cover and streamflow characteristics. Vegetation has the greatest controlling influence on width/depth ratio and stability in C, Da, E, and G channels, and a moderate influence on B, D, and F type channels (Rosgen 1996). Clary and Webster (1989) suggest a stubble height of 4 to 6 inches following fall livestock grazing to protect streambanks.

The following table presents a summary of information contained in Belsky et al. (1999) regarding influences, responses, causes, and effects of livestock grazing on channel morphology. Belsky et al (1999) utilize 30 citations to create the portion of the table summarized below.

**Table 24. Influences, responses, causes and impacts of livestock grazing on channel morphology. Table is recreated from data presented in Belsky et al. (1999).**

| Influence on | Response | Causes | Impacts |
|---|---|---|---|
| Channel depth | Increases | Incision due to increased flood energy in high gradient, erosional areas | Lowered groundwater table<br>Narrowed riparian zone<br>No flood plain development<br>Increased deposition downstream |
| Channel width | Increases | Trampling of streambanks<br>Increased erosion from increased flood velocity | Additional loss of riparian vegetation<br>Increased water temperatures |

| Influence on | Response | Causes | Impacts |
|---|---|---|---|
| | | Erosion of streambanks due to loss of riparian vegetation | Decreased water depth |
| Channel stability during floods | Decreases | Bare streambanks and channel bed erode | Widening of channel<br>Loss of pools and meanders |
| Channel bed – gravels | Lost due to erosion | Increased flood velocity and energy<br>Reduction in large woody debris | Reduced spawning habiatat<br>Reduced habiat for benthic organisms |
| Channel bed – fine sediment | Increase due to deposition | Increased streambank erosion | Fish eggs and fry die due to suffocation<br>Reduced habitat for benthic organisms<br>Loss of pool volume |
| Water depth | Decreases | Wider stream bed | Increased water temperatures<br>Reduced habiat |
| Streambank stability | Reduced | Fewer plant roots to anchor soil<br>Less plant coverage<br>Trampling | Increased sloughing<br>Increased erosion<br>Increased turbidity<br>Increased channel width |
| Streambank angle | Greater than 90 degrees | Sloughing<br>Trampling | Increased channel width<br>Decreased water depth |
| Streambank undercuts | Reduced | Mechanical breakdown of stream bank by livestock<br>Loss of vegetation | Decreased cover<br>Decreased pool numbers |
| Channel form | Decreased meander pattern<br>Increased unvegetated gravel bars | Increased water velocity<br>Loss of stabilizing vegetation<br>Erosion | Increased erosion<br>Decreased pool numbers<br>Decreased streambank roughness |
| Pools | Decrease in number and quality | Loss of large woody debris<br>Increased sedimentation | Loss of fish habitat<br>Loss of thermal refugia<br>Reduced salmonid productivity and survival |

### *Water Quality (Issue 7)*

Impacts of livestock grazing on water quality are associated with the amount, duration, and timing of runoff, erosion and sedimentation, pathogens, nutrients, water temperature and dissolved solids. Water quality is a function of the ability of riparian vegetation to filter or convert excess nutrients, organic compounds, trace metals, sediment, and chemicals found in water (Preston and Bedford 1988). Riparian vegetation is influential on hydrologic function through processes that are variable in both time and space (Abouguendia 2001).

**Temperature** – Livestock grazing can affect water temperatures by reducing canopy cover, overhanging bank vegetation, contributing to channel widening and decreased water depth, or reducing summer low flows (Belsky et al. 1999, Li et al. 1994). Typically water temperatures increase because of the above causative agents. The causes can influence evaporation rates, habitat quality and quantity for fish and macroinvertebrates, and alteration of food webs among other effects.

**Nutrients** – Livestock grazing causes known increases in nutrient concentrations. Runoff, urine, and manure are causes of increased nutrient concentrations. This in turn can reduce dissolved oxygen levels and cause changes in species composition downstream (Belsky et al. 1999).

**Sediment and Turbidity** – Livestock grazing causes known increases in sediment loads and turbidity. Instream disturbance, removal of streambank vegetation, erosion, and increased peak flows are four known causes of increased levels of sediment and turbidity (Belsky et al. 1999). This in turn can affect spawning and rearing success of fish, reduce dissolved oxygen levels in substrates, disrupt feeding and movements of fish and aquatic macroinvertebrates, and reduce reservoir storage capacity among other effects (Belsky et al. 1999).

**Dissolved Oxygen** – Livestock grazing can cause decreases in dissolved oxygen levels. Three potential causes of decreased DO levels include higher water temperatures and greater oxygen demand from algae and fecal material. These causes can lead to impacts on spawning success, survival, and growth of fishes, reduced decomposition rates, and increased toxicity of toxicants (Belsky et al. 1999).

**Bacteria** – Livestock grazing is known to cause increases in bacteria levels in streams. Fecal matter and disturbance of sediments that have trapped bacteria are two causes of increased bacteria levels. Introduction of fecal matter occurs by direct deposition or via runoff. Sediments are typically disturbed through hoof action. Two impacts of increased bacteria levels are higher potential for disease-producing pathogens being present and increased risk of exposure to disease through water contact (Belsky et al. 1999).

The causes and linkages between livestock grazing and affects to hydrologic resources are complicated and many. The following figure is a conceptual model of the linkages between livestock grazing and impacts to water quality described in Belsky et al. (1999). This illustration best shows the highly complicated and interrelated nature of livestock grazing causes and impacts to water quality parameters

### *Stream Flow Pattern*

### Overland Flow (Runoff), Peak Flow, Flood Water Velocity

Livestock grazing affects infiltration rates. The primary causes are soil compaction, reduced ground cover, and reduced infiltration rates. As infiltration rates decrease a corresponding increase in runoff and erosion is expected.

Increased runoff increases sheet and rill erosion, resulting in stream sedimentation. Increased peak runoff also increases stream energy for bank erosion, downcutting, and gully formation. Reductions in infiltration and storage reduce the magnitude and duration of late season flows.

Future infiltration rates are dependent on grazing intensities, past management, and recovery processes. Recovery varies with soil texture, moisture conditions, freeze-thaw relations, cover conditions, livestock grazing system utilized, etc. Stephenson and Veigel (1987) found two growing seasons insufficient time for complete recovery. Wheeler et al. (2002) found hydrologic recovery in one year on a location that had been rested for 35 years, grazed heavily once, and had a high percentage of organic matter in the first five centimeters of soil. These two studies show recovery begins quickly, is dependent on the system utilized, and varies considerably.

### Summer and Late Season Flows

Livestock grazing can cause decreases in summer and late season stream flow. A lowered water table and less water stored in riparian soils are two causes of lower stream flows. Reduction in stream flows in the summer and late season can cause stress to aquatic organisms through reduced amounts of habitat (Belsky et al. 1999), crowding, and higher water temperatures (Belsky et al. 1999, Li et al. 1994).

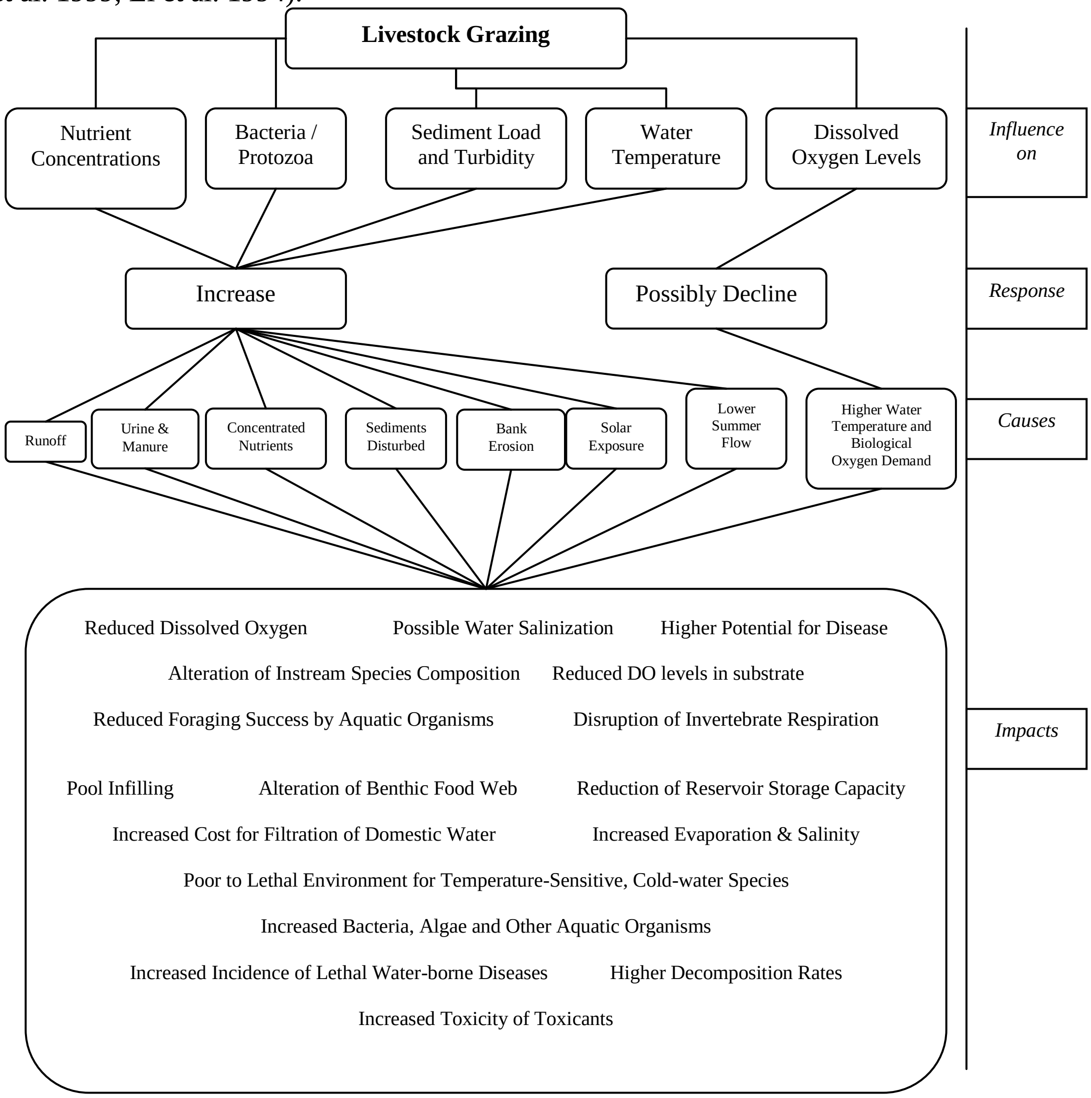


**Figure 6. Flow chart showing influences, responses, causes and impacts of livestock grazing on water quality. Diagram is adapted from information in Belsky et al. (1999).**

## Water Table

The water table can be lowered by affects of livestock grazing. Livestock grazing can cause decreased infiltration rates and increase runoff. Decreased infiltration leads to less water being stored in riparian soils, which would be available later in the year. Increased runoff leads to erosion, which can reduce groundwater recharge by the stream (Belsky et al. 1999) and cause the channel to downcut. As the water table is lowered, additional impacts begin to express themselves such as reduced rates of hyporheic flow, changes in riparian vegetation composition, and size of riparian zone.

The following two figures are conceptual models of the linkages between livestock grazing and impacts to five areas of stream flow patterns described in Belsky et al. (1999). These illustrations best show the highly complicated and interrelated nature of livestock grazing causes and affects to stream flow pattern.

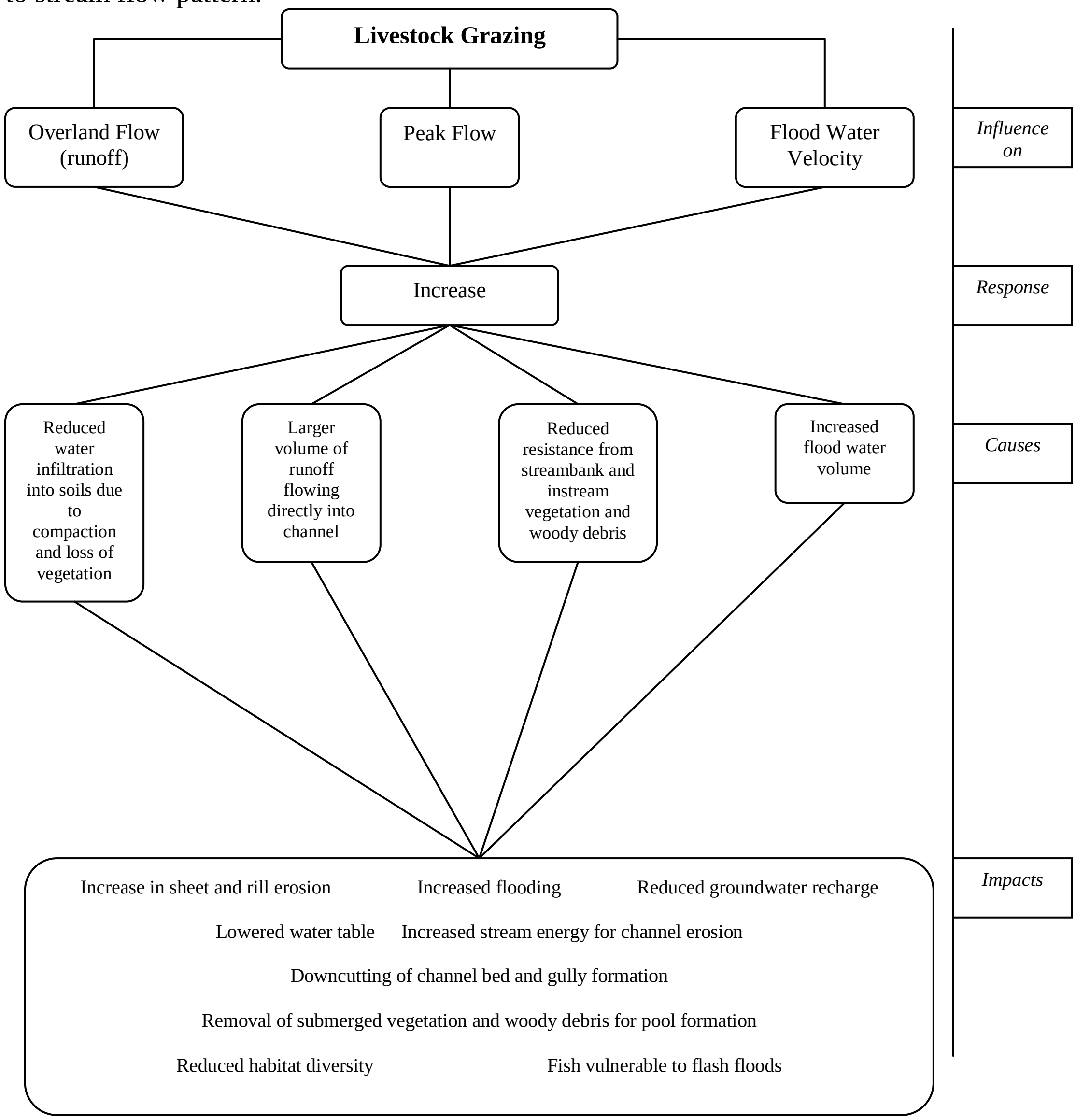


**Figure 7. Flow chart showing influences, responses, causes and impacts of livestock grazing on three parameters of stream flow pattern. Diagram is adapted from information in Belsky et al. (1999).**

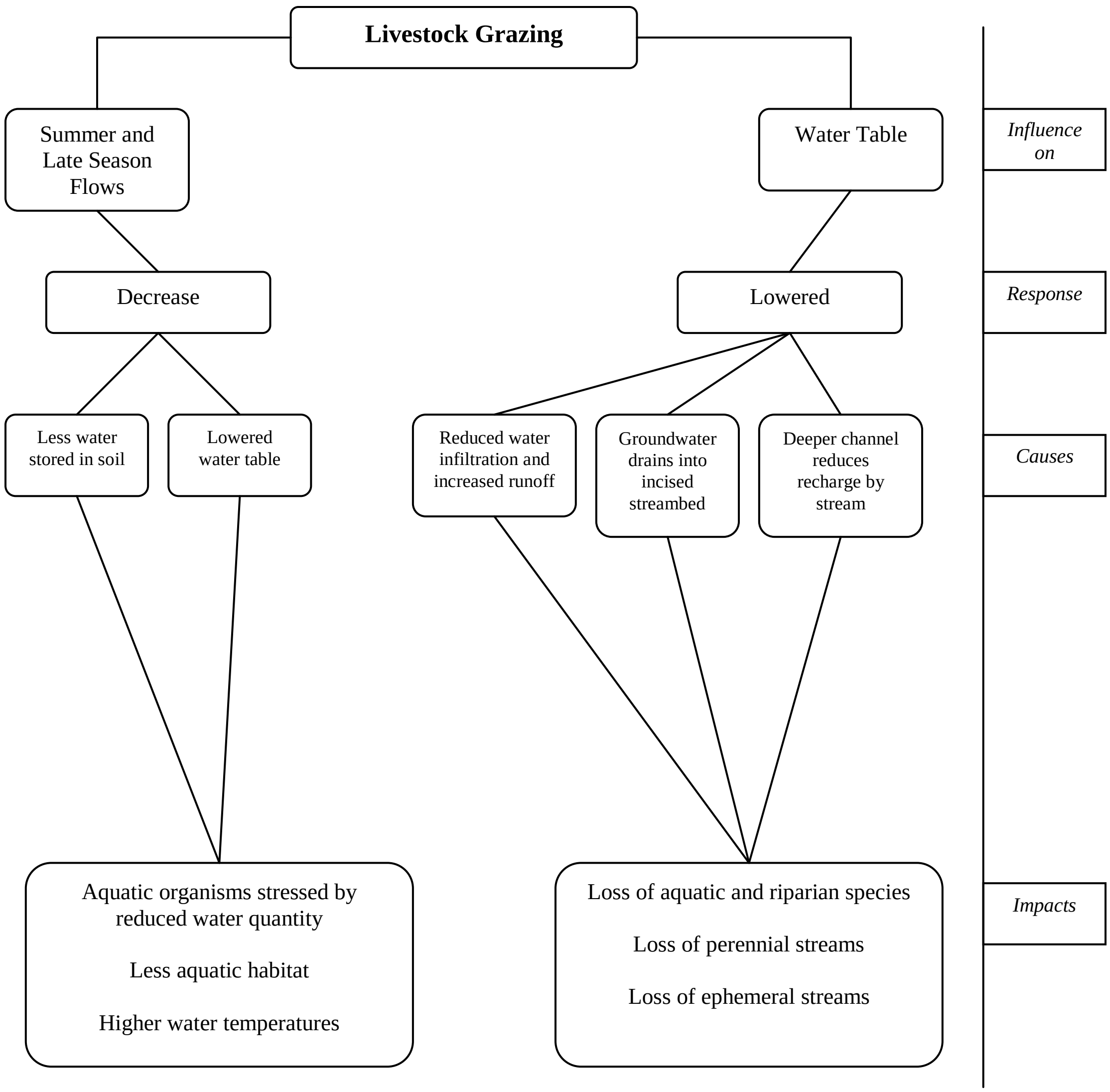


**Figure 8. Flow chart showing influences, responses, causes and impacts of livestock grazing on two parameters of stream flow pattern. Diagram is adapted from information in Belsky et al. (1999).**

## *Streambank Soils (Issue 3)*

Soil effects identified by Belsky et al. (1999) can be lumped into two general categories, 1) soil disturbance, and 2) ground cover. The degree and rate at which these effects are expressed is determined by the type, intensity, duration and timing of livestock grazing.

**Soil disturbance:** Livestock grazing can directly cause an increase in soil compaction (Belsky et al. 1999). Trampling of soils via hoof action (Wienhold et al. 2002) and the reduction of litter and organic matter can lead to an increase in soil compaction. Trampling and reduction of litter and organic matter can lead to lower infiltration rates, higher runoff, reduced plant productivity, and reduced cover of soils by plants (Belsky et al. 1999).

Livestock grazing causes soil compaction, especially when soils are wet. Bulk density increased in the 5 to 10cm and 10 to 15cm depths following heavy livestock grazing (Wheeler et al. 2002). Van Haveren (1983) found bulk densities of fine textured soils to be higher in heavily grazed pastures when compared to lightly grazed and moderately grazed pastures. Stephenson and Veigel (1987) found significant differences in soil bulk densities with increased stocking rates. When soils are saturated or near field capacity, puddling may also occur. Detrimental compaction and puddling occurs where livestock concentrate or trail to water, salting grounds, and along stock driveways.

Livestock grazing can indirectly cause an increase in erosion of soil (Belsky et al. 1999.) The authors identified three causes for the increase associated with livestock grazing, consumption or trampling of vegetation and soil compaction. These three mechanisms can lead to higher sediment delivery to streams and loss of fertile topsoil (Belsky et al. 1999).

Livestock grazing can indirectly cause a decrease in the litter layer covering soils (Belsky et al. 1999). Consumption of vegetation by livestock causes a decrease in the litter layer. This can in turn lead to drier, warmer soils, higher erosion rates, lower infiltration rates, higher runoff and reduced soil organic matter (Belsky et al. 1999).

Livestock grazing can indirectly cause a decrease in infiltration rates in soils (Belsky et al. 1999). Infiltration rates declined in the 5 to 10cm and 10 to 15cm depths following heavy livestock grazing (Wheeler et al. 2002). Belsky et al. (1999) identified four livestock related causes leading to a decrease in infiltration rates. Vegetation is consumed and trampled, soils are compacted via hoof action, and the amount of litter and organic matter is reduced. This can lead to higher erosion rates, reduced soil coverage from plants, and increased rates of overland flow, decreased soil water content and a lowered water table (Belsky et al. 1999).

Livestock grazing can indirectly cause a decrease in soil fertility (Belsky et al. 1999). Soil trampling via hoof action and reduced amounts of litter and organic matter cause a reduction in fertility. This can lead to a loss of fertile topsoil and reduced numbers of soil organisms (Belsky et al. 1999).

**Ground cover:** A reduction in ground cover can affect soil fertility. The reduction in fertility can be caused by soil trampling via hoof action and reduced amounts of litter and organic matter. This can lead to a loss of fertile topsoil and reduced numbers of soil organisms (Belsky et al. 1999).

A vigorous plant community leads to greater root density, mass, and depth, which in turn provides greater resistance to erosion and streambank compression and shear (Clary and Kinney 2002). Heavy livestock grazing affects species composition (Wienhold et al. 2002) which can lead to a less vigorous plant community.

The impacts identified by Belsky et al. (1999) directly and indirectly lead to other impacts. These impacts can occur to soils as well as other resources. A discussion of the complicated relationships to other resources is beyond the scope of this document. Refer to referred literature for such discussions.

### *Fisheries (Issue 6)*

Change below was made after Ratner gave us this redd trampling article.

Livestock grazing typically does not directly affect fisheries; the effect is usually indirect. Indirect effects may include reduced spawning, hatching and rearing success from higher levels of fine sediment, and decreased, or a shift in food availability as a result of habitat changes. Indirect effects also include a loss or simplification of habitat due to increased levels of fine sediment, channel widening, bank trampling or shearing, and loss/removal of riparian vegetation. Direct and indirect effects to other resources are ultimately expressed in fish due to individuals and populations being dependent on the processes that form and drive stream habitats.

While research has simulated and modeled the potential effects of redd trampling by cattle on trout populations (Gregory and Gammett 2009, Peterson et al. 2010), additional work is needed to test underlying assumptions regarding in situ rates of redd trampling and trampling-related mortality before effects on trout populations of the Bighorn National Forest can be accurately predicted.

Livestock ~~use of~~ activity in riparian ecosystems can affect the streamside environment by changing, reducing, or eliminating vegetation (Platts 1991). Livestock grazing, through changes in channel morphology and lowering of the water table (Platts 1991), may eliminate riparian areas. The water column can be altered by increasing water temperatures, nutrients, suspended sediments, bacterial counts, and by altering the timing and volume of water flow. Livestock grazing can also cause bank sloughing, create false or retreating banks, and accelerate sedimentation resulting in silt degrading spawning and food production areas. These impacts on the water column can result in decreased fish habitat and biomass.

Riparian vegetation plays a critical role in influencing the health and condition of fish habitat and aquatic communities. It provides cover for fish, stabilizes stream banks, helps control stream temperature, and provides food. The importance of cover to fish is well documented. Binns and Eiserman (1979) found cover a significant predictor of biomass in Wyoming trout streams. Li et al. (1994) reported a negative correlation between trout abundance and solar input.

Research done in the southwest United States has shown five factors to affect conclusions regarding effects of livestock grazing on fish populations (Rinne 1999). These factors also apply to fisheries on the Bighorn National Forest.

- Species of fish (salmonids vs. non-salmonids)
- Temporal and spatial variation
- Habitat influences
- Fishery management influences
- Natural factor influences

The influence of natural variation must be considered when determining livestock grazing effects on fish. Platts (1991) stated, "The combined influences of geology, climate, soil, vegetation, and water runoff often create unstable stream conditions even without livestock grazing." Rinne (1999) stated, "Because natural stream systems are inherently dynamic, perhaps chaotically so in the arid American Southwest, land use impacts on aquatic habitats and their respective fish populations are often difficult to separate from those that occur naturally."

Rinne (1999) raises questions about the lack of data and reliability of available data regarding fish-grazing relationships. Platts (1991) summarizes 21 studies and Rinne (1999) summarizes 30 studies regarding fish and livestock grazing, and both recognize many studies contain design errors. Errors include lack of pre-treatment data and no replication (Rinne 1999).

## *Effects Common to Action Alternatives*

Riparian and stream systems are complicated and dynamic, making it difficult to write the exact effects livestock grazing has on them. Land managers accept there are effects of livestock grazing on resource areas regardless of management strategy (Kauffman and Krueger 1984).

Effects analysis of livestock grazing specific to suitable acres will not occur within this report. Suitable grazing acres are not used to determine AUM's, and livestock grazing occurs on acreage not identified as suitable range. Therefore, effects to aquatic and soil resources from livestock grazing will be analyzed within the entire project or analysis area, not specific to suitable acres.

Effects are analyzed assuming that all Best Management Practices (BMPs) are being met. If BMPs are not met in either action alternative, there could be additional environmental effects. Monitoring is intended to measure BMP implementation and effectiveness, and adjustments to livestock grazing could be made based upon this monitoring (Bighorn National Forest Vegetation Grazing Guidelines 2007 and Forest Plan 2005).

## Hydrology (Issues 3 and 7)

The action alternatives, Alternative 2 and Alternative 3, could cause effects to hydrologic resources when compared to no livestock grazing (Alternative 1). The effects of both action alternatives would be the same, as BMPs are applied and met in both alternatives.

The following description of effects assumes the Bighorn National Forest Vegetation Grazing Guidelines (USFS 2007) are followed and best management practices are applied to ensure allowable use. If guidelines and BMPs are not met, there could be additional environmental effects not considered in this document.

Based on the geographic location of the Bighorn National Forest and knowledge of forest personnel, it is realistic to suggest livestock grazing produces similar influences, causes, and impacts to hydrologic resources as those documented in research. Livestock grazing could cause removal and damage of streamside vegetation, affect channel morphology by alteration of substrate, alteration of pool to riffle ratios, and widen the channel. Livestock grazing could also continue to affect water quality and streambank soils. The influences on and response of hydrologic resources is dependent on many linked causative agents (Belsky et al. 1999).

These causative agents could lead to a wide range of impacts. The impacts include, but are not limited to, narrowed riparian zone, increased water temperature, widening of channel, increased erosion, increased sedimentation, decreased cover (Belsky et al. 1999), and simplification and loss of instream habitats.

The risk and level of impact to hydrology resources from livestock grazing could vary across the project area, and could be most severe in areas that are heavily used, provide easy access to livestock, or are very susceptible to disturbance. Despite the acknowledged effects, Alternatives 2 and 3 are designed to meet or exceed forest plan standards and guidelines, thus minimizing risk.

**Streamside Vegetation:** Livestock grazing could affect streamside vegetation. Removal of vegetation via browsing and physical damage of vegetation through hoof action and rubbing could continue to occur. Loss and damage of vegetation can lead to a wide range of responses in the riparian area. Responses include, but are not limited to, decreased water quality, increased water temperature, and alteration of stream flow patterns. The effects of these responses may include reduced dissolved oxygen levels, increased risk of disease-bearing pathogens being present in the water, increased evaporation, alteration of food webs, and reduction or loss of habitat for temperature sensitive species (Belsky et al. 1999).

Standards, guidelines, and BMPs outlined in Appendix A provide direction for management of riparian vegetation. The intent of standards and guidelines and BMPs is to provide adequate residual vegetation in order to prevent adverse affects. Both action alternatives could maintain desired conditions in areas already in this state. Both action alternatives could eventually meet desired conditions in degraded areas. Alternative 3 could meet desired conditions faster than Alternative 2 because it incorporates adaptive management.

**Channel Morphology:** Livestock grazing could affect channel morphology, such as channel widening, altering substrate, and sediment deposition, within and downstream of the allotment boundaries (Belsky et al. 1999).

Alternatives 2 and 3 could result in elevated levels of sedimentation in stream channels when compared to no livestock grazing (Alternative 1). Localized effects are most obvious in watering and crossing areas; however, it is expected this effect could not be detectable over background levels a short distance downstream. Periods of higher flow could scour these areas and redistribute the sediment. Fine sediment could also be imported to these areas from upstream. As a result, it could be unlikely that small changes in fine sediment levels could be detected and attributed to current livestock grazing.

Alternatives 2 and 3 could cause some level of disturbance to streambanks and riparian vegetation, which can result in impacts to channel morphology. The level of effect to streambanks would depend on the amount directly affected by livestock. The level of effect on riparian vegetation would depend on the timing, intensity, and duration of use by livestock.

**Water Quality:** In Alternatives 2 and 3, livestock grazing would continue in the project area. Livestock grazing is known to cause increases in bacteria levels in streams. Fecal matter and disturbance of sediments that have trapped bacteria are two causes of increased bacteria levels (Belsky et al. 1999). This effect is localized to streams and lakes. Bacteria levels are expected to be highest in areas where livestock gather and spend extended periods or within the water influence zone. Current levels of bacteria in the Big 6 allotments are unknown.

Both alternatives would not change the risk of bacterial contamination. Meeting grazing standards would provide sufficient vegetative cover in the upland and riparian zones to act as a filter. The residual vegetation would be sufficient to prevent overland runoff, which can transport bacteria directly to the stream or waterbody. This design criterion is included in each action alternative.

**Stream Flow Pattern:** The action alternatives would not alter surface runoff or hydrograph timing or intensity within the analysis area. A livestock grazing strategy that incorporates timing, intensity, and duration/frequency, as well as meeting grazing guidelines and forest plan standards and guidelines, would provide sufficient vegetative cover as well as minimizing soil compaction. This would ensure measurable increases in runoff and changes in stream flow patterns would not occur. These design criteria are included in each action alternative.

In summary, a livestock grazing strategy that incorporates timing, intensity, and duration/frequency as well as meeting grazing guidelines and forest plan standards and guidelines would minimize the risk of increased fine sediment, streambank alteration, over utilization of riparian vegetation, or altering plant communities. This could also provide for the protection and maintenance of upland and riparian areas. Development and implementation of such a grazing strategy is included as a design criterion in each action alternative. Neither action alternative is expected to have a long-term (>10 yr) negative effect on watershed condition due to the incorporation of design criteria.

## Soils (Issue 3)

The action alternatives, Alternative 2 and Alternative 3, could cause effects to soils when compared to no livestock grazing (Alternative 1). The effects of both action alternatives would be the same, as BMPs are applied and met in both alternatives. Regardless of stubble height or residual vegetation prescribed for an allotment or by alternative, the intent is to leave sufficient vegetative cover to protect resource areas (USFS 2007).

Based on the geographic location of the Bighorn National Forest and knowledge of forest personnel, it is realistic to suggest livestock grazing produces similar influences, causes, and effects on soils as those documented in research. Livestock grazing could cause increases in bare ground, erosion, and soil compaction as well as causing decreases in the protective litter layer, infiltration rates, and soil fertility. These influences and response of soils would be caused by vegetation being consumed, vegetation being trampled, and soils being compacted and trampled via hoof action and reduced amounts of litter and organic matter (Belsky et al. 1999).

These causative agents could lead to a wide range of impacts. These impacts include, but are not limited to, drier soils, higher erosion rates, higher runoff, higher sediment delivery to streams, loss of topsoil, lower infiltration rates, reduced plant productivity, reduced plant cover, higher overland flow, lower soil water content, lowered water table, fewer soil organisms and reduced amount of soil organic matter.

Examples of affected areas include trail corridors, water developments, salting locations, streambanks, open/wet meadows, springs, seeps, and riparian stringers. These areas are particularly sensitive to disturbance when soils are wet or moist, which typically occurs during the early portion of the livestock grazing season. However some sites may remain wet or moist throughout the year.

The risk and level of impact to soils from livestock grazing would vary across the project area, and would be most severe in areas that are heavily used, provide easy access to livestock, or are very susceptible to disturbance. Despite these acknowledged effects, the action alternatives are designed to meet or exceed forest plan standards and guidelines, thus minimizing risk to soils.

Research in the western United States has documented the above referenced influences, causes, and impacts on soils. Selected references include Belsky et al. 1999, Clary et al. 1996, Clary and Webster 1989, Kauffman and Krueger 1984, Kovalchik and Elmore 1992, Platts 1991, Platts and Nelson 1985, and Wheeler et al. 2002.

Alternatives 2 and 3 would allow livestock grazing on sensitive soil types (see Existing Condition section above). Sensitive soils are found in within the allotment boundaries.

"Activity Area" definition change was made after Tommy J's and Ratner's comments.

Despite the acknowledged affected soils, it appears that WCPH direction is being met. This conclusion was derived by estimating the amount of detrimentally affected soils and comparing it to the following WCPH direction: "Manage land treatments to limit the sum of severely burned soil and detrimentally compacted, eroded and displaced soil to no more than 15% of any activity area." The WCPH (FSH 2509.25) defines Activity Area as: "*an area of land impacted by a management activity ranging from a few acres to an entire watershed depending on the type of monitoring being conducted. It is commonly a timber sale cutting unit, a prescribed fire burn unit or an allotment pasture.*" Applying this 15% to the activity area means 58,810 acres of soil within the allotment boundaries would have to be detrimentally affected for the action alternatives to violate WCPH direction.

Changes below were made after Tommy John pointed out the Tongue River Gateway soil is not sensitive to grazing. Also, the number of water developments was corrected by Amy Ortner. This reduced the acres of sensitive soil in the PA.

Potentially affected soils in the project area allotments were estimated to be ~~31,249~~ 15,866 acres. This estimate was derived using the following assumptions:

- All sensitive soil types within the project area were assumed to be affected: ~~29,450~~ 14,380 acres

- Water developments, including proposed developments, were assumed to be approximately one acre each: ~~603~~ 290 acres
- A 3-foot-wide strip on both sides of every foot of perennial and intermittent stream in the project area was assumed to be affected: 1,196 acres

This process overestimates the amount of affected soils. It is unlikely that every acre of sensitive soil is detrimentally affected. ~~For example, the Tongue River-Gateway soils are typically vegetated by lodgepole pine, Engelmann spruce, and grouse whortleberry. None of these plants are desired forage for livestock, so assuming all 15,070 acres of Tongue River- Gateway soils to be detrimentally affected over-estimates the impacted area.~~ Assuming one acre at each watering site is thought to be a relatively accurate estimate of affected soils. Some sites are smaller than one acre in size and some are larger. The assumption that all stream banks being detrimentally affected is also an overestimate. Field visits confirm that there are areas affected by livestock grazing, but not every foot of streambank is damaged.

The following section was added based on Tommy John's and Ratner's comments:

In addition to analyzing soils within the entire project area allotments, soils were analyzed on non-forested acres within the allotment boundaries. Non-forested allotment acres were evaluated using the Bighorn National Forest R2veg GIS data, totaling 119,083 non-forested acres or approximately 30% of the total allotment acres.

Detrimentally affected soils on non-forested acres within the project area allotments were estimated to be 433 acres (0.36% of the non-forested allotment acres). This estimate was derived using the following:

- Assume watering developments, including proposed developments, within non-forested allotment acres are affected by approximately one acre each: 237 acres
- Assume a 3-foot-wide strip along every mile of fence (152 miles), existing and proposed, within non-forested allotment acres is affected due to livestock trailing: 55 acres
- Estimation of site-specific detrimentally affected soils, identified by the range conservationists on all three districts, within non-forested allotment acres: 141acres (see "Site-Specific Soils" in the "Existing Conditions" section above).

Using non-forested acres within the allotment boundaries as the activity area, 17,862 acres of soil within the activity area would have to be detrimentally affected for the action alternatives to violate WCPH direction (15% of the activity area). The analysis above, which includes site-specific observations within non-forested allotment boundaries, indicates that 433 acres (0.36%) of soils are detrimentally affected. Therefore, WCPH direction is being met.

There is no difference in risk to soils between the action alternatives in terms of impacts from livestock grazing. Best management practices would be met, and the intent of implementing BMPs is to provide adequate protection to a resource.

In summary, livestock grazing is known to have affects on soil resources, and effects could occur if Alternative 2 or Alternative 3 were implemented. The influence, response, cause, and impacts of livestock grazing are numerous with complex interrelationships, making it difficult to write exactly what those effects and their consequences are. However, it is acknowledged that livestock grazing would affect soils, including sensitive, upland, and riparian soils within the project area. These effects would vary by spatial and temporal scale. The inclusion of vegetation grazing guidelines and WCPH direction in both alternatives minimizes the risk to soils.

## Fisheries (Issue 6)

The action alternatives, Alternative 2 and Alternative 3, could cause effects to fisheries resources when compared to no livestock grazing (Alternative 1). The effects of both action alternatives would be the same, as ~~BMPs~~ best management practices (BMPs) are applied and met in both alternatives. The following description of effects assumes the Bighorn National Forest Vegetation Grazing Guidelines (USFS 2007) are followed and ~~best management practices~~ BMPs are applied to ensure allowable use. If guidelines and BMPs are not met, there could be additional environmental effects not considered in this document.

Implementation of either action alternative could affect fishery resources. The effects would be the same due to BMPs being applied in both alternatives. Regardless of stubble height or residual vegetation prescribed for an allotment or by alternative, the intent is to leave sufficient vegetative cover to protect resource areas (USFS 2007).

Livestock could affect trout populations by trampling their spawning redds (Gregory and Gammett 2009; Peterson et al. 2010). Research has simulated and modeled the potential effects of redd trampling by cattle on trout populations. However, additional work is needed to test underlying assumptions regarding in situ rates of redd trampling and trampling-related mortality before effects on trout populations of the Bighorn National Forest can be accurately predicted.

Based on the geographic location of the Bighorn National Forest and knowledge of forest personnel, it is realistic to suggest livestock grazing produces similar influences, causes, and impacts to soil and hydrologic resources as those documented in research (e.g. Platts 1991). Livestock grazing would continue to affect these resources and eventually indirectly affect fish habitat and populations.

Because some of the cause-and-effect relationships are indirect, it is difficult to predict ~~exactly what would happen~~ the level of disturbance to fish habitat and populations as a result of continuing ~~to graze~~ livestock grazing. Possible effects include simplification and loss of habitat, and reduced spawning, hatching, and rearing success. These effects are mainly caused by sedimentation.

The first response of streams to increased sediment is ~~to~~ reduced roughness (Heede 1980), usually by filling pools with sediment. Subsequent adjustments may include changes in width, depth, meander pattern, or longitudinal profile. When these adjustments take place, fish populations typically decline (Platts 1991). The risk and level of these effects is not known but could occur at some level due to the known effect of sedimentation from livestock grazing. It is unlikely that measurable changes in fine sediment could be linked to livestock grazing.

Healthy riparian areas stabilize stream channels, provide storage for sediment, serve as nutrient sinks for surrounding watersheds, and improve ~~the water leaving the watershed~~ water quality (DeBano and Schmidt 1989, Platts 1991). Thus, healthy riparian areas provide the best conditions for good fish habitat and populations. Riparian habitats are susceptible to disturbance and degradation but are also durable and can recover rapidly when managed correctly (DeBano and Schmidt 1989).

In brief, effects to other resources such as soils and components of riparian zones could eventually affect fish habitat and populations. Sedimentation is thought to be the main indirect agent affecting fisheries. A healthy riparian zone ~~is better able to~~ can ~~lessen~~ reduce the influences of livestock grazing ~~influences~~ and provide~~s~~ a dynamically stable environment for fisheries. The combined influences of geology, climate, soil, vegetation, and water runoff often create unstable stream conditions even without livestock grazing (Platts 1991); therefore, it is difficult to describe and quantify the indirect cause-and-effect relationships between livestock grazing and fisheries.

Changes made below to Alt 1 (pink text) based on Laurie's request to discuss removal of range improvements, 4-29-2011.

# Alternative 1 – No Action

Under Alternative 1, no domestic livestock grazing would be permitted. No additional fuel management or vegetation treatment of aspen, sagebrush, or conifers would occur as part of this NEPA decision. Most existing range structural improvements not needed for wildlife or other purposes would be abandoned or removed with specific decisions to be made administratively regarding disposition.

## Direct and Indirect Effects

### *Hydrology (Issues 3 and 7)*

Alternative 1 would remove permitted livestock grazing from the project area, and livestock grazing would no longer affect aquatic resources. Conditions that exclude livestock use would result in the fastest recovery rate of riparian areas and associated components (Myer and Swanson 1995). Components contributing to watershed condition would begin to move towards a dynamic equilibrium. The rate and amount of response to removal of livestock grazing would vary across the project area spatially and in time.

Plant vigor and composition would be expected to increase and progress towards a natural composition (if not already present or progressing to) after livestock grazing is removed from riparian areas. The rate at which this would occur is dependent upon the existing condition of the watershed including soils, vegetation, and continuing other activities. Measurable changes in habitat conditions following removal of livestock grazing are documented in studies such as Meyer and Swanson (1995). Platts (1991) reviewed 21 studies and found 20 of them to show habitat improvement in previously grazed systems when livestock grazing was removed. Kovalchik and Elmore (1992) found mid to late season livestock grazing incompatible with willow growth and survival. The authors note cattle begin to utilize willows when riparian forage utilization reached 45% (4 to 6 inch stubble height). Willow vigor and density is expected to increase following removal of livestock grazing.

Streambank stability is expected to increase as vegetation recovers. Meyer and Swanson (1995) found bank stability to increase at a higher rate in an ungrazed stream compared to a stream subjected to deferred rotation livestock grazing. The ungrazed stream also had more shrubs and willows present. The authors suggest the difference in shrub density is due to livestock grazing on shrubs. The findings of Kovalchik and Elmore (1992) support this suggestion. Platts and Nelson (1985) suggest vegetation growth during periods of rest from livestock grazing is not accompanied by improvements in deteriorated streambanks.

In areas impacted by livestock grazing, ~~S~~streambanks would no longer be subjected to hoof action, which can cause trampling and shearing. Additionally, vegetation would become more diverse and dense on streambanks impacted by livestock. This is especially true in areas where livestock water or cross streams when trailing. As banks revegetate and stabilize, undercut banks and complex stream habitats would begin to develop.

Summer water temperatures are expected to decrease as shrub cover increases. Shrubs provide overhead cover and shade the stream. Li et al. (1994) found lower maximum daily water temperatures in watersheds with greater riparian canopy. Platts and Nelson (1989) found a significant difference between canopy density in grazed and ungrazed sites in the Rocky Mountains. Canopy density was 60% higher and thermal input to streams was 12% less at ungrazed sites (Platts and Nelson 1989). The rate of temperature change would be slow and depend on the existing condition of the riparian area, soils, vegetation, and continuation of other land disturbing activities.

Removal of livestock grazing would decrease sediment levels in streams. This would result from increased bank stability, decreased bank trampling, and increased sediment filtering capability.

This alternative does not treat sagebrush. (However, it should be noted that sagebrush may be treated under different NEPA decisions, i.e. Southwest Fuels on the Powder River Ranger District). As sagebrush continues to grow, it could become denser and add to the risk of a wildfire. Wildfire can detrimentally affect soils by heating them to the point where they become hydrophobic and increasing erosion rates within a watershed. The effect of wildfire on soils could have a corollary effect on revegetation of riparian and upland areas and sedimentation in streams. Wildfire is within the natural range of variation, and soils damaged by wildfire could recover over time. Recovery time would vary and be dependent on factors such as slope, aspect, elevation, plant regrowth, fire severity, fire intensity, and precipitation following the fire. The exclusion of livestock grazing from this area would allow soils, riparian and upland areas, and streams/stream processes subjected to wildfire to better withstand effects and recover at the fastest rate possible.

The removal of range structural improvements (stock tanks, livestock fences, etc.) may result in short-term soil disturbances upon immediate removal. This could temporarily affect hydrologic resources if waterbodies are in close proximity to the range structures. However, the long-term effect will benefit soils, and therefore hydrologic resources as soils recover.

In review, Alternative 1 would remove livestock grazing from the project area and not manage sagebrush. Livestock grazing effects to riparian zones and stream channels would no longer occur. As these areas moved towards a dynamic equilibrium, the overall watershed health would increase. This alternative provides the greatest protection of and benefit to aquatic resources.

### *Soils (Issue 3)*

Alternative 1 would remove permitted livestock grazing from the project area and livestock grazing would no longer affect soils, including sensitive soil types, in the project area. The effects of livestock grazing associated with recreational use would continue, but this is outside the scope of analysis in this report.

This alternative provides the greatest benefit and protection for soils. This alternative allows soils to recover and achieve desired conditions at the fastest rate. The other alternatives could eventually meet desired conditions across the project area, if they are not already, but at a slower rate due to the continuation of livestock grazing.

Livestock grazing would no longer cause increases in bare ground, erosion and soil compaction as well as causing decreases in the protective litter layer, infiltration rates and soil fertility. Vegetation would no longer be consumed or trampled by livestock. Livestock would no longer compact or trample soils. The amount of litter and organic matter would increase following the removal of livestock grazing.

As these causative agents were removed from the landscape, impacts associated with livestock grazing would no longer occur. These impacts include, but are not limited to, drier soils, higher erosion rates, higher runoff, higher sediment delivery to streams, loss of topsoil, lower infiltration rates, reduced plant productivity, reduced plant cover, higher overland flow, lower soil water content, lowered water table, fewer soil organisms and reduced amount of soil organic matter (Belsky et al. 1999; Kauffman and Krueger 1984).

Soils currently affected by livestock grazing would recover in several ways. The quality of soils (see Desired Condition section above) would increase as the amount of bare ground, erosion, and compaction decreased. Bare ground and erosion would decrease as plants colonized areas. Compaction would decrease via freeze/thaw and plant root growth.

The quality of soils would also improve as the litter layer, infiltration rates and fertility of soils increased. Plant growth would add to the litter layer as well as increase infiltration rates by decreasing compaction. Additionally, soils would no longer be disturbed by the hoof action of permitted livestock, which causes displacement and erosion. It is estimated these beneficial effects could begin to be expressed within one to two years after removal of livestock and continue until the soil had achieved a dynamic equilibrium.

This alternative does not treat sagebrush. (However, it should be noted that sagebrush may be treated under different NEPA decisions, i.e. Southwest Fuels on the Powder River Ranger District). As sagebrush continues to grow, it would become denser and add to the risk of a wildfire. Wildfire can detrimentally affect soils by heating them to the point where they become hydrophobic. Wildfire is within the natural range of variation, and soils damaged by wildfire would recover over time. Recovery time would vary and be dependent on factors such as slope, aspect, elevation, plant regrowth, fire severity, fire intensity, and precipitation following the fire. The exclusion of livestock grazing from this area would allow soils subjected to wildfire to better withstand effects and recover at the fastest rate possible.

The removal of range structural improvements (stock tanks, livestock fences, etc.) may result in short-term soil disturbances upon immediate removal. However, the long-term effect will benefit soil resources as soils recover via the processes discussed above.

In summary, Alternative 1 removes known livestock grazing effects to soil resources. Soils affected by past and current livestock grazing would recover. Recovery would occur through processes such as freeze/thaw and plant growth. Recovery would begin following removal of livestock grazing and continue until the soil had achieved a dynamic equilibrium. The processes associated with recovery would occur on soils within the allotment boundaries analyzed in this project. This alternative provides the greatest benefit to and protection for soils over the long-term.

### *Fisheries (Issue 6)*

Fish habitat, individuals, and populations would benefit from removal of livestock grazing and the removal of range structural improvements. The following benefits (described in the soils and hydrology sections) would eventually benefit fisheries resources:

- Measurable changes in habitat conditions following removal of livestock grazing are documented in studies such as Meyer and Swanson (1995).
- Bank stability increased at a higher rate in an un-grazed stream compared to a stream subjected to deferred rotation livestock grazing. The un-grazed stream also had more shrubs and willows present (Kovalchik and Elmore 1992, Meyer and Swanson 1995).
- Canopy density, stream shading, thermal input, and stream temperatures are different when comparing grazed to un-grazed sections of stream (Li et al. 1994, Platts and Nelson 1989)
- Removal of livestock grazing would decrease sediment levels in streams. This would result from increased bank stability, decreased bank trampling and increased sediment filtering capability.

In addition, there would be no possibility of livestock trampling trout redds under this alternative.

This alternative does not treat sagebrush. (However, it should be noted that sagebrush may be treated under different NEPA decisions, i.e. Southwest Fuels on the Powder River Ranger District). As sagebrush continues to grow, it would become denser and add to the risk of a wildfire. Wildfire can affect a watershed by temporarily increasing erosion and removing vegetative cover. Wildfire is within the natural range of variation and watersheds recover over time. Recovery time would vary and be dependent on factors such as slope, aspect, elevation, plant regrowth, fire severity, fire intensity, and precipitation following the fire. The exclusion of livestock grazing from this area would allow areas subjected to wildfire to better withstand effects and recover at the fastest rate possible.

The removal of range structural improvements (stock tanks, livestock fences, etc.) may result in short-term soil disturbances upon immediate removal. This could temporarily affect fish habitat if waterbodies are in close proximity to the range structures. However, the long-term effect will benefit soil resources, and therefore fish habitat, as soils recover and are colonized by plants.

In summary, Alternative 1 removes known livestock grazing effects to watershed components, and conditions that exclude livestock use would result in the fastest recovery rate of riparian areas and associated components (Myer and Swanson 1995). Areas affected by past and current livestock grazing would recover. Soils and vegetative recovery would eventually affect fisheries by reducing sedimentation, increasing cover, decreasing water temperatures and provide a dynamically stable environment for fish to occupy.

## Cumulative Effects

### *Hydrology (Issues 3 and 7)*

Activities considered in the cumulative effects analysis are past and present domestic livestock grazing, timber harvest, fire suppression, wildfire, dispersed recreation and motorized trail use, fisheries habitat projects, flow augmentation for irrigation, and a water conveyance special use permit. All of these activities have the potential to negatively impact hydrologic conditions. See the Connected Actions, Past, Present, and Foreseeable Activities Relevant to Cumulative Effects Analysis section above for a full description of these activities and the associated impacts to hydrologic resources.

This alternative provides the greatest protection for and benefit to aquatic resources. Hydrologic conditions would improve following the removal of livestock, and in response, the effects of other activities would lessen, which would contribute to increased watershed health.

Under alternative 1, the lack of conifer and sagebrush treatments in the Beaver Creek and Little Horn project areas has the potential to cumulatively impact hydrologic resources, if a landscape scale fire occurs within the project area. However, wildfire is within the natural range of variation, and the removal of livestock grazing impacts would allow soils, riparian and upland areas, and streams/stream processes subjected to wildfire to better withstand effects and recover at the fastest rate possible.

### *Soils (Issue 3)*

The removal of livestock grazing would improve soil conditions in the project area and in response, the effects of other activities (past livestock grazing, timber harvest, fire suppression, past wildfire, and dispersed camping and motorized trail use) would lessen, which would contribute to increased watershed health. However, the lack of vegetation treatments may increase the risk of wildfire. Therefore, soils may be detrimentally impacted if a high severity, high intensity fire occurred within the project area. As sagebrush and conifers continue to grow, they would become more dense and add to the risk of a wildfire. Wildfire can detrimentally affect soils by heating them to the point where they become hydrophobic. Wildfire is within the natural range of variation, and soils damaged by wildfire would recover over time. Recovery time would vary and be dependent on factors such as slope, aspect, elevation, plant regrowth, fire severity, fire intensity, and precipitation following the fire. The exclusion of livestock grazing from this area would allow soils subjected to wildfire to better withstand effects and recover at the fastest rate possible.

### *Fisheries (Issue 6)*

This alternative provides the greatest protection for, and benefit to, fisheries resources. Hydrologic conditions would improve following the removal of livestock, and in response, the effects of other activities would lessen, which would contribute to increased watershed health and improved conditions for fish.

The lack of conifer and sagebrush treatments under alternative 1 has the potential to cumulatively impact hydrologic resources, if a landscape-scale fire occurs within the project area. However, wildfire is within the natural range of variation, and the removal of livestock grazing impacts would allow soils, riparian and upland areas, and streams/stream processes subjected to wildfire to better withstand effects and recover at the fastest rate possible.

~~The removal of permitted livestock grazing under Alternative 1 would not add cumulatively to impacts from any past, current, or reasonably foreseeable actions. Hydrologic and soil conditions would improve following the removal of livestock, and in response, the effects of other activities would lessen, which would contribute to increased watershed health.~~

~~Fire suppression has increased the risk of a large, stand-replacing wildfire occurring in the analysis area. Landscape scale fire has not occurred in the analysis area watersheds for over a century and the timber (mostly lodgepole pine) is relatively even-aged and increasingly susceptible to a fire of this type. Removal of livestock grazing would add an unknown amount of fine fuels to the watershed. These fine fuels would allow fire to carry better across open areas between timber stands. This would add to the risk of a large, stand-replacing fire occurring. If conditions were sufficient, (high temperatures, high wind, low relative humidity, etc.) a fire would carry through these areas regardless of livestock grazing.~~

### Compliance with Forest Plan and Other Relevant Laws, Regulations, Policies and Plans

Recommendations made within this report follow the direction provided in the revised Forest Plan. The Forest Plan was prepared to meet laws and regulations such as the Forest and Rangeland Renewable Resources Planning Act (1974), NFMA (1976), and NEPA (1969).

## *Alternative 2 – Livestock Grazing with Current Management*

Under Alternative 2, livestock grazing would continue as prescribed under the current allotment management plans (AMPs) or, in the absence of such a plan, under the annual operating instructions (AOIs). No additional fuel management or vegetation treatment of aspen, sagebrush or conifers beyond existing signed decisions would occur.

### Design Criteria

Numerous design criteria were identified during the review of the Watershed Conservation Practices Handbook (WCPH, USFS 2006), Appendix A, which includes design criteria identified for inclusion into ground-disturbing activities. The appendix provides a detailed review of WCPH, while the list below summarizes the most applicable design criteria.

1. Meet established riparian grazing standards (stubble height).
2. Any restoration of organic ground cover will use certified weed free local plants as practicable.
3. Manage livestock use through control time/timing, intensity, and duration/frequency of use in riparian areas and wetlands to maintain or improve long-term stream health.
4. Pesticides will be used for intended purposes and applied according to label direction.

Effectiveness monitoring for the implementation of Best Management Practices (i.e., WCPH direction/design criteria) will be conducted on the Bighorn National Forest by randomly-selecting grazing allotments and pastures for BMP review. Each year, three BMP grazing reviews are conducted, one on each district. These reviews may or may not be immediately conducted for allotments within this project area, but in time, the randomized process will select Big 6 allotments and interdisciplinary reviews will be conducted to ensure BMPs are being met and to identify opportunities for improvement.

## Direct and Indirect Effects

### *Hydrology (Issues 3 and 7)*

Alternative 2 would continue livestock grazing within the project area under current management and not manage sagebrush. Effects such as removal or damage of riparian vegetation and streambank disturbance would continue. These effects would be localized, discontinuous, and occur as long as livestock continued to graze the project area. Discussion of effects of livestock grazing on streamside vegetation, channel morphology, water quality, stream flow pattern, and streambank soils are covered in the Review of Potential Effects from Livestock Grazing and the Effects Common to Action Alternatives sections above.

Current livestock management that meets grazing guidelines and forest plan standards and guidelines would maintain or slowly improve aquatic resource conditions within the project area. The intent of vegetation grazing guidelines, WCPH direction, and forest plan standards and guidelines is to provide adequate protection for a resource area. Combining these sources of direction would provide protection for and minimize risk to watershed health.

The effects of not treating sagebrush would be the same as described in Alternative 1.

For aquatic resources, Alternative 2 would pose the greatest risk from a management implementation perspective. This strategy allows managers to deal with situations as they arise; however, there are areas in which this management strategy is insufficient or slower in meeting or moving towards desired conditions. This alternative would not allow managers a wide range of options to address rapidly watershed health issues as they were identified within the allotments. This alternative also does not treat sagebrush, which could contribute to decreased watershed health in the long-term.

### *Soil (Issue 3)*

Alternative 2 would implement current livestock grazing under existing AMPs and AOIs, and would not alter existing soil conditions within the project area. The inclusion of vegetation grazing guidelines and WCPH direction minimize the risk of affecting soils. The freeze/thaw cycle and plant growth could help reverse the annual effect contribution. Regardless of the minimal risk to soils, this alternative would cause effects.

For soil resources, Alternative 2 poses the greatest risk from a management implementation perspective. This strategy allows managers to deal with situations as they arise; however, there are areas in which this management strategy is insufficient or slower than necessary in meeting or moving toward desired conditions. This alternative would not allow managers a wide range of options to address soil issues rapidly as they were identified within the allotments. This alternative also does not treat sagebrush, which could contribute to decreased watershed health in the long-term.

Effects such as soil compaction, displacement, and erosion would continue, and areas of heavy use such as trails, watering areas and stream crossings would be the most susceptible. The influence on, response of, causes, and impacts to soils from livestock grazing would be the same as those reviewed previously in the Effects Common to Action Alternatives section above. Sites potentially in an unacceptable condition (trails, watering areas, stream crossings, etc.) are discontinuous and thought to comprise less than 15% of the project area.

The rationale behind meeting WCPH direction is as follows:

1. A worst case scenario was developed. All sensitive soils, all streambanks, and all stock watering developments were considered "detrimentally" affected. This equals ~~31,249~~ 15,866 acres.
2. 15% of the project area was calculated. This equals ~~58,640~~ 58,836 acres.
3. The value in Step 2 (~~58,640~~ 58,836 acres) is greater than Step 1 (~~31,249~~ 15,866 acres); therefore, less than 15% of the project area is detrimentally affected and WCPH direction is not being violated.

This worst case scenario is not a true representation of existing condition and as such, it overestimates effects. Field visits confirm that not every acre of sensitive soil, foot of streambank, and stock watering development are detrimentally affected. This analysis shows, regardless of exact acreage of affected soil, WCPH direction is being met within the project area.

This alternative does not treat sagebrush. The effects of not treating sagebrush would be the same as described in Alternative 1.

In summary, Alternative 2 would cause direct and indirect effects to soils, including sensitive soils within the allotment boundaries. Effects would include soil compaction, displacement, and erosion. These effects would occur within the allotment boundaries, last as long as livestock grazing continues, and vary in intensity temporally and spatially. Inclusion of design criteria such as vegetation grazing guidelines, WCPH and Forest Service soil handbook direction will minimize the risk of livestock grazing affecting soils in the project area. Additionally, not treating sagebrush could increase the risk of affecting soils.

### *Fisheries (Issue 6)*

Alternative 2 would continue livestock grazing and not manage sagebrush. Continuing to graze livestock would affects soils, riparian areas, and stream channels, all of which ultimately affect fish habitat and populations. Meeting livestock grazing direction provided by the 2005 Forest Plan and other guiding documents would minimize these effects. Alternative 2 would meet desired conditions, but at a slower pace than no livestock grazing (Alternative 1) or grazing under adaptive management (Alternative 3). The lack of sagebrush management (see effects described under alternative 1) and lack of adaptive management strategies for livestock grazing create the greatest risk of affecting fish habitat and populations both in the short- and long-term.

Direct and ~~I~~indirect effects to fisheries would continue. Livestock could trample spawning redds (Gregory and Gammett 2009; Peterson et al. 2010) and ~~C~~causative agents such as sedimentation

~~would~~ could affect fisheries. Heavily used areas within the riparian zone would be most likely to affect fisheries. Describing the exact level of effect is not possible due to the indirect nature of cause-and-effect relationships between livestock grazing and fisheries. Some level of simplification and loss of habitat would occur in addition to reduced spawning, hatching, and rearing success.

Alternative 2 poses the greatest risk from a management implementation perspective. This strategy allows managers to deal with situations as they arise; however, there are areas in which this management strategy is insufficient or slower in meeting or moving towards desired conditions in uplands and riparian areas. This alternative would not allow managers a wide range of options to address rapidly watershed health issues as they were identified within the allotments.

## Cumulative Effects

### *Hydrology (Issues 3 and 7)*

The following past, present, and reasonably foreseeable future activities have contributed to changes in watershed condition, soil structure, sediment availability to aquatic habitats, and changes in water quality: past and current livestock grazing, timber harvest, fire suppression, wildfire, recreation, fish habitat projects, stream flow augmentation for irrigation, and water conveyance. The overall effects from these actions could have negative impacts to hydrologic resources. The continuation of livestock grazing under alternative 2 would add cumulatively to the effects from these activities.

Not treating sagebrush and conifer encroachment in alternative 2 may increase the potential for landscape scale wildfires. Should a high intensity, high severity wildfire occur within the project area, hydrologic resources could be impacted by high sediment delivery into waterbodies. This could add to the negative effects from the actions listed above.

### *Soil (Issue 3)*

The continuation of livestock grazing under this alternative could add cumulatively to the effects from past and current livestock grazing, timber harvest, fire suppression, wildfire, and recreation. Under Alternative 2, effects such as soil compaction, displacement, and erosion would continue, and areas of heavy use such as trails, watering areas and stream crossings would be the most susceptible. Recent wildfires, such as the 2007 Bone Creek Fire, have the potential to contribute to soil erosion and sediment delivery to streams. Recreation activities can compact and erode soils, increase overland flow, and provide a source of sediment into streams.

### *Fisheries (Issue 6)*

The following past, present, and reasonably foreseeable future activities have contributed to changes in watershed condition, soil structure, sediment availability to fisheries resources: past and current livestock grazing, timber harvest, fire suppression, wildfire, recreation, fish habitat projects, stream flow augmentation for irrigation, and water conveyance. The overall effects from these actions could have negative impacts to hydrologic resources and thus fisheries resources. The continuation of livestock grazing under alternative 2 would add cumulatively to the effects from these activities.

Not treating sagebrush and conifer encroachment in alternative 2 may increase the potential for landscape scale wildfires. Should a high intensity, high severity wildfire occur within the project area, hydrologic resources could be impacted by high sediment delivery into waterbodies. This could add to the negative effects from the actions listed above.

~~The effects of past, present, and foreseeable activities, as they relate to hydrology, soil, and fisheries resources (past and current livestock grazing, timber harvest, fire suppression, wildfire, recreation, fish habitat projects, stream flow augmentation for irrigation, and water conveyance), have contributed to changes in watershed condition, soil structure, sediment availability to aquatic habitats, and changes in water quality. The cumulative effect of livestock grazing would not add cumulatively because Best Management Practices, standards, and guidelines would be met, which provide adequate protection for hydrologic, soil, and fisheries resources within the allotment boundaries. With adequate protection, measureable incremental effects would not occur, therefore, implementing Alternative 2 would not add cumulatively.~~

~~Fire suppression has increased the risk of a large, stand-replacing wildfire occurring in the analysis area. Landscape scale fire has not occurred in the analysis area watersheds for over a century and the timber (mostly lodgepole pine) is relatively even-aged and increasingly susceptible to a fire of this type. Removal of livestock grazing would add an unknown amount of fine fuels to the watershed. These fine fuels would allow fire to carry better across open areas between timber stands. This would add to the risk of a large, stand-replacing fire occurring. If conditions were sufficient, (high temperatures, high wind, low relative humidity, etc.) a fire would carry through these areas regardless of livestock grazing.~~

### Compliance with Forest Plan and Other Relevant Laws, Regulations, Policies and Plans

Recommendations made within this report follow the direction provided in the revised Forest Plan. The Forest Plan was prepared to meet laws and regulations such as the Forest and Rangeland Renewable Resources Planning Act (1974), NFMA (1976), and NEPA (1969).

## *Alternative 3 – Livestock Grazing with Adaptive Management*

Under Alternative 3, livestock grazing would continue using adaptive management to focus on the end results for the resource, as opposed to selecting one specific course of action that will not be deviated from over time. The treatment of approximately 19,719 acres of sagebrush and conifer encroachment in the Shell Canyon (Beaver Creek watershed) and Little Horn Geographic Areas would also occur. In addition, spikemoss treatment is an adaptive management strategy proposed for the Tourist, Rapid Creek, and Big Goose allotments in the Goose Creek project area.

### Design Criteria

Numerous design criteria were identified during the review of the Watershed Conservation Practices Handbook (WCPH, USFS 2006), Appendix A, which includes design criteria identified for inclusion into ground-disturbing activities. The appendix provides a detailed review of WCPH, while the list below summarizes the most applicable design criteria.

1. Meet established riparian grazing standards (stubble height).
2. Any restoration of organic ground cover will use certified weed free local plants as practicable.
3. Manage livestock use through control time/timing, intensity, and duration/frequency of use in riparian areas and wetlands to maintain or improve long-term stream health.
4. Firelines will not be built in, or around, wetlands unless needed to protect life, property, or the wetland. If construction is necessary, handline is preferred over mechanical line construction.

5. Pesticides will be used for intended purposes and applied according to label direction.
6. Spikemoss treatment will not occur during periods of heavy rain or wet soils.
7. Soil disturbance during spikemoss treatments will not introduce soil into streams, swales, lakes, or wetlands.
8. Sites disturbed by spikemoss treatment would be reseeded with a native seed mix, if revegetation does not occur naturally.
9. Heavy equipment for spikemoss treatment will only occur on dry soils, when soil moisture is below the plastic limit.

Effectiveness monitoring for the implementation of Best Management Practices (i.e., WCPH direction/design criteria) will be conducted on the Bighorn National Forest by randomly-selecting grazing allotments and pastures for BMP review. Each year, three BMP grazing reviews are conducted, one on each district. These reviews may or may not be immediately conducted for allotments within this project area, but in time, the randomized process will select Big 6 allotments and interdisciplinary reviews will be conducted to ensure BMPs are being met and to identify opportunities for improvement.

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## Direct and Indirect Effects

### *Hydrology (Issues 3 and 7)*

Alternative 3 would allow livestock grazing to continue; however, AMPs and AOIs would be adjusted to incorporate adaptive management strategies. Continuation of livestock grazing would result in localized, discontinuous streambank and riparian vegetation disturbance. Design measures incorporated into this alternative, such as vegetation grazing guidelines and forest plan standards and guidelines, are expected to maintain or improve aquatic resource conditions throughout the project area. The intent of these guiding documents is to provide adequate protection for and minimize risk to watershed health.

Alternative 3 would implement new stock water developments, whereas Alternatives 1 and 2 would not. The intent of new water developments is to improve distribution of livestock and help maintain or improve hydrologic conditions by drawing livestock away from specific riparian areas. Some of the proposed water developments in Alternative 3 include building reservoirs in swales: naturally occurring low areas that collect snowmelt water. This action goes against Watershed Conservation Practices Handbook design criteria 12.1.m: "Do not excavate earth material from, or store excavated earth material, in any stream, swale, lake, wetland, or WIZ." Storing material in swales impairs the long-term health of the watershed and the riparian ecosystem condition. This action disrupts the flow regime by damning water that flows downstream during runoff events. While Alternative 3 proposes to store earth material in swales to build stock water reservoirs, this action also has benefits to aquatic resources by better distributing livestock throughout grazing allotments, away from streams and riparian areas where livestock concentrate.

The use of prescribed fire, by chemical or mechanical means, to manage sagebrush would have no short- (< 5 yr) or long-term (> 10 yr) measurable effect on aquatic resources within the analysis or project area. Treatment of sagebrush would benefit watershed health by reducing the risk of wildfire. Diversity in sagebrush density and canopy cover would result in a mosaic burn pattern with differing levels of burn intensity and severity. This pattern would mimic natural burn conditions.

Lesser spikemoss (*Selaginella densa*) is a native plant that forms a dense mat on dry, upland, low gradient sites. Spikemoss tends to dominate large areas of rangeland where it reduces plant community diversity. When disturbed, spikemoss has poor revegetation potential (Crane 1990). Spikemoss control, proposed as an adaptive management strategy in Alternative 3, involves mechanical treatment that would harrow or chisel the soil to a depth of approximately 4-6 inches on 50-300 acre plots within the Tourist, Rapid Creek, and Goose Creek allotments in the Goose Creek project area. This action breaks up the spikemoss surface cover. Treatment areas would be on upland sites with less than 10% slopes, away from water influence zones. Treatment areas would be seeded with a native seed mix where necessary, and would be rested from livestock grazing until vegetation is well established. Direct effects to hydrologic resources would be minimal, as spikemoss grows in dry, low gradient, upland sites, and does not grow near aquatic/riparian ecosystems. This ensures that soil disturbances due to mechanical spikemoss treatment would not occur near waterbodies. The treatment of spikemoss mats may indirectly affect the hydrologic cycle as spikemoss mats absorb nearly all available water during low intensity rainfall events, which decreases the potential for runoff and erosion (Van Dyne and Vogel 1967). However, there is no evidence that an increase in surface runoff and erosion would be measurable, when comparing a landscape vegetated by spikemoss mats to a landscape vegetated by native grasses. Infiltration of water into the soil profile is determined by a number of factors (surface slope, soil surface roughness, hydraulic conductivity of the surface, etc.) which will be altered during mechanical treatment. In addition, field studies show that infiltration rates vary greatly over short distances due to animal activity, plant associations, and small-scale topographic changes (Dingman 2002).

Another adaptive management strategy includes closing domestic sheep allotments near the Devil's Canyon bighorn sheep herd. This would be done after other adaptive management strategies fail to limit interactions between bighorn sheep and domestic sheep. If this adaptive management strategy occurs, domestic sheep allotments would be closed to livestock grazing. ~~However, removing livestock improvements and/or restocking vacant allotments with cattle would require further NEPA analysis; therefore these actions are not covered in this analysis.~~ If domestic sheep are removed from these allotments, hydrologic resources would recover from any impacts caused by livestock grazing and would provide an overall benefit to aquatic resources. For further detail, see the Hydrology section above under Alternative 1, which describes removing livestock grazing from all allotments.

For aquatic resources, Alternative 3 presents the middle ground in terms of management implementation. This alternative allows managers to more rapidly and effectively deal with aquatic resource issues than Alternative 2, but desired conditions would not be met as quickly as Alternative 1. Alternative 3 also allows managers to implement and evaluate different management measures and strategies, whereas Alternative 2 is more restrictive in management options. Alternative 3 reduces the risk of high severity and intensity fire within sagebrush dominated areas thus adding to overall watershed health.

In summary, Alternative 3 would continue livestock grazing within the project area and manage sagebrush. Continuing to graze livestock would have effects to streamside vegetation, channel morphology, water quality, stream flow pattern, and streambank soils. Meeting livestock grazing direction provided by the 2005 Forest Plan and other documents would minimize these effects. Alternative 3 would meet desired conditions faster than Alternative 2, but at a slower pace than no livestock grazing. The inclusion of sagebrush management and adaptive management strategies for livestock grazing make this alternative the middle ground between removal of livestock and continuing livestock grazing under current management.

### *Soil (Issue 3)*

Alternative 3 would allow livestock grazing to continue and treat sagebrush; however, AMPs and AOIs would be adjusted to incorporate adaptive management strategies. The inclusion of sagebrush treatments, adaptive management, the Bighorn National Forest Vegetation Grazing Guidelines, WCPH, and soil handbook (FSH 2509.18) direction minimize the risk of affecting soils. The freeze/thaw cycle and plant growth would help reverse the annual effect contribution. Regardless of the minimal risk to soils, this alternative would cause effects.

Of the two action alternatives, Alternative 3 poses the least risk of detrimental effects to soil resources. Design criterion would allow areas with degraded soil conditions to recover more rapidly than Alternative 2, but not as fast as Alternative 1. This alternative allows managers to more rapidly and effectively deal with soil related situations than Alternative 2. Alternative 3 allows managers to implement and evaluate different management measures and strategies, where as Alternative 2 is more restrictive in management options.

Continuation of livestock grazing would result in localized, discontinuous soil compaction, displacement, and erosion throughout the project area. Areas of heavy use such as trails, watering areas and stream crossings would be most susceptible to effects. The addition of new stock water developments would impact soils locally around each watering site, but would lessen the impact to soils in existing watering locations, such as riparian areas and wetlands, as the distribution of livestock is improved. The influence on, response of, causes to, and impacts to soils from livestock grazing would be the same as those reviewed previously in the Effects Common to Action Alternatives section. Sites potentially in an unacceptable condition (trails, watering areas, stream crossings, etc.) are discontinuous and thought to comprise less than 15% of the project area. The rationale behind meeting WCPH direction is the same as described in Alternative 2. Implementing Alternative 3 would not add additional measurable effects to soils. This is due to the inclusion of design criteria, adaptive management, and treatment of sagebrush.

Fuel management and vegetation treatment of aspen, sagebrush, and conifers would have no short (< 5 yr) or long-term (> 10 yr) measurable effect on soil structure or productivity. Acres of vegetation treated annually will vary. Regardless of acres, treated units and treatment methods will be designed to minimize negative effects.

Spikemoss control, proposed as an adaptive management strategy in Alternative 3, involves mechanical treatment that would harrow or chisel the soil to a depth of approximately 4-6 inches on 50-300 acre plots that have slopes less than 10% within the Tourist, Rapid Creek, and Goose Creek allotments in the Goose Creek project area. Proposed treatments would occur on two soil types: Fourmile loam (map unit 18) and Lucky-Burgess-Hazton association (map unit 25). The Fourmile loam is a deep, well drained soil found on old terraces that formed from alluvium derived dominantly from granite (Nesser 1986). The soil permeability is moderate, hazard of water erosion is slight, and the Fourmile has no major limitations for producing forage. The Lucky-Burgess-Hazton association formed in residuum derived dominantly from granite. This association has a slight hazard of water erosion, and the major limitation for producing forage is the droughtiness of the Hazton unit. However, the Lucky and Burgess units are found on gently sloping areas, and the Hazton unit is on more steeply sloping areas and ridges (Nesser 1986). Therefore, the Hazton soil should not be affected by the spikemoss treatments, as treatment areas are on level gradients.

Spikemoss treatment would directly disturb the soil surface. Soil mixing would occur at a depth of approximately 4-6 inches, the soil surface roughness would be increased, as the spikemoss is uprooted. The low gradient treatment areas limit potential hillslope erosion, as spikemoss mats are found on level gradients. Treatment areas would be rested from livestock grazing until vegetation is well established and would be reseeded where necessary to allow for long-term revegetation.

Another adaptive management strategy includes closing domestic sheep allotments near the Devil's Canyon bighorn sheep herd. This would be done after other adaptive management strategies fail to limit interactions between bighorn sheep and domestic sheep. If domestic sheep are removed from these allotments, soil resources would recover from any impacts caused by livestock grazing and would provide an overall benefit to soil resources. For further detail, see the Soil section above under Alternative 1, which describes removing livestock grazing from all allotments.

Design measures incorporated into this alternative, such as vegetation grazing guidelines and forest plan standards and guidelines, are expected to maintain or move soils towards desired conditions throughout the project area. These design criteria should provide sufficient residual vegetation to protect soil associations from erosion.

In summary, this alternative poses the least risk to soils of the two action alternatives. The inclusion of listed design criteria, adaptive management, and treatment of sagebrush, aspen, and conifers combine to provide the least risk to soils of the two action alternatives. This alternative would meet desired conditions faster than Alternative 2, but not as fast as Alternative 1.

### *Fisheries (Issue 6)*

Alternative 3 would allow livestock grazing to continue; however, AMPs and AOIs would be adjusted to incorporate adaptive management strategies. Closing domestic sheep allotments near the Devil's Canyon bighorn sheep herd is an adaptive strategy under this alternative, as is the proposed treatment of spikemoss in the Tourist, Rapid Creek, and Big Goose allotments (Goose Creek project area). This alternative would also treat sagebrush, aspen, and conifer encroachment in the Beaver Creek and Little Horn project areas. The inclusion of sagebrush, aspen, and conifer treatments, adaptive management, vegetation grazing guidelines, and WCPH and soil handbook (FSH 2509.18) direction minimize the risk of affecting soils and riparian areas, which ultimately affect fisheries.

The continuation of livestock grazing could trample trout spawning redds (see discussion under Effects Common to Action Alternatives above) and ~~would~~ could result in localized, discontinuous effects to other resources. Effects include soil compaction, soil displacement, erosion, removal and damage of riparian vegetation, altering channel morphology, water quality, and stream flow pattern. These effects would in turn have unknown effects to fisheries within the analysis area. These effects would not be measurable and could not be linked directly to livestock grazing. Watersheds are dynamic and attributing measurable incremental impacts on fisheries to prescribed levels of livestock grazing is doubtful.

Alternative 3 would continue to graze livestock within the project area, ~~and~~ manage sagebrush, and may treat spikemoss under an adaptive management strategy. Continuing to graze livestock would have effects to soils, riparian areas, and stream channels. All of which ultimately affect fish habitat and populations. Meeting livestock grazing direction provided by the 2005 Forest Plan and other guiding documents would minimize these effects. Alternative 3 would meet desired conditions more rapidly than Alternative 2 but not as quickly as Alternative 1. Spikemoss treatments should not have measurable effects to fisheries resources, as the treatments would occur on dry, level gradient, upland sites away from water influence zones. If domestic sheep are removed from the allotments near the Devil's Canyon bighorn sheep herd, fisheries resources would recover from any impacts caused by sheep grazing and would provide a long-term benefit to fish and aquatic resources. The inclusion of sagebrush management and adaptive management strategies for livestock grazing make this alternative the middle ground between removal of livestock and continuing livestock grazing under current management.

## Cumulative Effects

### *Hydrology (Issues 3 and 7)*

The following activities were determined to be relevant to cumulative effects analysis for hydrology resources: past and current livestock grazing, timber harvest, fire suppression, wildfire, recreation, fish habitat projects, stream flow augmentation for irrigation, and water conveyance. The overall effects from these actions could have negative impacts to hydrologic resources. The continuation of livestock grazing under alternative 3 would add cumulatively to the effects from these activities.

Treating sagebrush and conifer encroachment under alternative 3 decreases the potential for landscape scale wildfires and therefore reduces the risk of post-fire high sediment delivery into waterbodies within the project area. This positive benefit could offset negative effects from the past, present, and reasonable foreseeable future actions listed above.

### *Soil (Issue 3)*

The continuation of livestock grazing under this alternative could add cumulatively to the effects from the following activities: past and current livestock grazing, timber harvest, fire suppression, wildfire, and recreation. However, alternative 3 poses less risk of cumulative effects to soils than alternative 2 because of the actions proposed and adaptive management options available under this alternative.

Under Alternative 3, effects such as soil compaction, displacement, and erosion would continue, and areas of heavy use such as trails, watering areas and stream crossings would be the most susceptible. Recent wildfires, such as the 2007 Bone Creek Fire, have the potential to contribute to soil erosion and sediment delivery to streams. Recreation activities can compact and erode soils, increase overland flow, and provide a source of sediment into streams. Adaptive management spikemoss treatment would disturb the soil surface at a depth of approximately 4-6 inches on 50-300 acre plots in three allotments within the Goose Creek project area. Effects would be minimal as spikemoss grows on level gradients and treatment areas would be re-seeded with native seed mix where necessary and rested from livestock grazing until revegetated.

### *Fisheries (Issue 6)*

The following activities were determined to be relevant to cumulative effects analysis for fisheries resources: past and current livestock grazing, timber harvest, fire suppression, wildfire, recreation, fish habitat projects, stream flow augmentation for irrigation, and water conveyance. The overall effects from these actions could have negative impacts to fisheries resources. The continuation of livestock grazing under alternative 3 would add cumulatively to the effects from these activities.

Treating sagebrush and conifer encroachment under alternative 3 decreases the potential for landscape scale wildfires and therefore reduces the risk of post-fire high sediment delivery into waterbodies within the project area. This positive benefit could offset negative effects from the past, present, and reasonable foreseeable future actions listed above.

~~The effects of past, present, and foreseeable activities, as they relate to hydrology, soil, and fisheries resources (past and current livestock grazing, timber harvest, fire suppression, wildfire, recreation, fish habitat projects, stream flow augmentation for irrigation, and water conveyance),~~

~~have contributed to changes in watershed condition, soil structure, sediment availability to aquatic habitats, and changes in water quality. The cumulative effect of livestock grazing would not add cumulatively because Best Management Practices, standards, and guidelines would be met, which provide adequate protection for hydrologic, soil, and fisheries resources within the allotment boundaries. With adequate protection, measureable incremental effects would not occur, therefore, implementing Alternative 3 would not add cumulatively.~~

~~Fire suppression has increased the risk of a large, stand-replacing wildfire occurring in the analysis area. Landscape scale fire has not occurred in the analysis area watersheds for over a century and the timber (mostly lodgepole pine) is relatively even-aged and increasingly susceptible to a fire of this type. Removal of livestock grazing would add an unknown amount of fine fuels to the watershed. These fine fuels would allow fire to carry better across open areas between timber stands. This would add to the risk of a large, stand-replacing fire occurring. If conditions were sufficient, (high temperatures, high wind, low relative humidity, etc.) a fire would carry through these areas regardless of livestock grazing.~~

### Compliance with Forest Plan and Other Relevant Laws, Regulations, Policies and Plans

Recommendations made within this report follow the direction provided in the revised Forest Plan. The Forest Plan was prepared to meet laws and regulations such as the Forest and Rangeland Renewable Resources Planning Act (1974), NFMA (1976), and NEPA (1969).

## Monitoring Recommendations

Six long-term stream monitoring sites exist within the project area. These sites are strategically located to represent effects to $6^{th}$-level watersheds. Channel morphology and vegetative information is collected at each location. These sites were established as part of Forest Plan monitoring and can be used to provide information about the implementation of this project. Because these sites are part of a forest-wide monitoring effort it is not necessary to designate them as required monitoring in this NEPA decision.

Additional monitoring may be added as issues are identified during the adaptive management process. No additional NEPA would be required to implement the monitoring determined necessary to evaluate adaptive strategies.

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# Appendix A: Watershed Conservation Practices Handbook Review

The following table tracks whether the Watershed Conservation Practices Handbook (WCPH) design criteria are adopted, amended, or not used. It is based on the May 5, 2006 WCPH (FSH 2509.25, Chapter 10). Per Forest Plan Soil, Water, Riparian and Wetland Guideline 1, the WCPH is applicable to all project-level decisions on the Bighorn National Forest. However, in some cases, WCPH design criteria are either not applicable, the Forest Plan has other direction, or the project-level NEPA decision includes other site-specific direction. The WCPH can be found in its entirety at: Watershed Conservation Practices Handbook 2509.25

Additional Design Criteria are provided in Chapter 2 of the EIS, which are not specific to WCPH guidance, but may provide additional protection of soil and aquatic resources.

| WCPH Description | WCPH Design Criteria | Design Criteria Adopted and Related Comments | Rationale for Not Adopting Specific Design Criteria |
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| **11 - Hydrologic Function** | | | |
| 11.1 - Manage land treatments to conserve site moisture and to protect stream health from damage by increased runoff. | a. In each watershed containing a 3rd order and larger stream, limit connected disturbed areas so the total stream network is not expanded by more than 10%.<br>b. Design the size, orientation, and surface roughness of forest openings to prevent scour and site desiccation. | a. No new roads will be constructed. Vegetation utilization will be managed using BNF grazing guidelines. | b. More applicable to timber sales. |
| 11.2 - Manage land treatments to maintain enough organic ground cover to prevent harmful increased runoff. | a. Maintain the organic ground cover of each activity area so that pedestals, rills, and surface runoff from the activity are not increased.<br>b. *Restore the organic ground cover of degraded activity areas within the next plan period, using certified local native plants as practicable; avoid persistent or invasive exotic plants. | a. Meeting grazing standards will maintain the organic ground cover so that pedestals, rills and surface runoff will not be increased.<br>b. Any restoration of organic ground cover will use certified weed free local plants.<br><br>*The WCPH (FSH 2509.25) definition of "activity area" is an allotment pasture. An activity area is not considered to be "degraded" until greater than 15% of the activity area has been impacted. Restoration of an area includes improvement, as well as complete recovery of the area (i.e. meeting or moving toward restoration). | NA |
| **12 - Riparian Areas and Wetlands** | | | |
| 12.1 - In the water influence zone | a. Allow no action that will cause long-term change to a lower | f. The proposed action incorporates timing, intensity, | a. Soil, Water, Riparian, and |

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| next to perennial and intermittent streams, lakes, and wetlands, allow only those actions that maintain or improve long-term health and riparian ecosystem condition. | stream health class in any stream reach.<br>b. Allow no action that will cause long-term change away from desired condition in any riparian or wetland vegetation community.<br>c. Keep heavy equipment out of streams, swales, and lakes, except to cross at designated points, build crossings, or do restoration work, or if protected by at least 1 foot of packed snow or 2 inches of frozen soil.<br>d. Ensure at least one-end log suspension in the WIZ. Fell trees in a way that protects vegetation in the WIZ from damage. Keep log landings and skid trails out of the WIZ, including swales.<br>e. Locate new concentrated-use sites outside the WIZ and outside riparian areas and wetlands. Armor or reclaim existing sites in the WIZ to prevent detrimental soil and bank erosion.<br>f. Manage livestock use through control time/timing, intensity, and duration/frequency of use in riparian areas and wetlands to maintain or improve long-term stream health.<br>g. Keep stock tanks, salt supplements, and similar features out of the WIZ and out of riparian areas and wetlands always.<br>h. Manage dry meadow and upland plant communities, including Kentucky bluegrass types that have invaded into wetland /riparian areas in a manner that will contribute to their replacement over time by more mesic native plant communities.<br>i. Do not allow any livestock grazing through an entire growing season in pastures that contain riparian areas and wetlands.<br>j. Design grazing systems to limit utilization of woody species.<br>k. Maintain the extent of stable banks in each stream reach at 74% or more of reference conditions.<br>l. Adjust management in riparian areas and wetlands to improve detrimental soil compaction whenever it occurs.<br>m. Do not excavate earth material from, or store excavated earth material, in any stream, swale, lake, wetland, or WIZ.<br>n. Emphasize natural stabilization processes consistent with the stream type and capability when restoring damaged stream banks. | and duration/frequency of livestock. Monitoring stubble height will allow managers to assess condition of riparian areas and trigger the appropriate adaptive management option(s).<br>g. Stock tanks, salt supplements, and other range improvements will be kept out of the WIZ and wetlands. Stock driveways will cross streams at designated areas.<br>h. Grazing standards are adopted and included in the proposed action as design criteria.<br>i. A grazing strategy suitable for these allotments was developed by the range conservationist and included in the proposed action.<br>j. A grazing strategy suitable for these allotments was developed by the range conservationist and included in the proposed action. This strategy will limit the utilization of woody species.<br>k. Meeting riparian grazing standards (stubble height) are expected to maintain bank stability.<br>l. Photo point monitoring as well as site visits will note if soil resources are deteriorating as evidenced by hummocking or platy surface structure. | Wetland Standard 1 from the BNF Forest Plan provides stronger direction for implementing this design criteria.<br>b. Desired conditions include the goal of maintaining or improving stream width to depth ratio as necessary.<br>c. More applicable to timber sales.<br>d. More applicable to timber sales.<br>e. More applicable to timber sales.<br>m. Proposed action goes against this design criterion, as Alternative 3 proposes to build stock water reservoirs in swales. See discussion in the Environmental Consequences section.<br>n. Channel restoration projects are not being considered in this project. |
| 12.2 - Design and construct all stream crossings and other instream structures to provide for passage of flow and sediment, withstand expected flood flows, and allow free movement of resident aquatic life. | a. Install stream crossings to meet Corps of Engineers and State permits, pass normal flows, and be armored to withstand design flows.<br>b. Size culverts and bridges to pass debris.<br>c. Install stream crossings on straight and resilient stream reaches, as perpendicular to flow, and to provide passage of fish and other aquatic life.<br>d. Install stream crossings to sustain bankfull dimensions of width, depth, and slope and keep streambeds and banks resilient.<br>e. Install or maintain fish migration barriers only if needed to protect endangered, threatened, sensitive, or unique native aquatic populations. | No design criteria are applicable. | These design criteria apply to new or reconstruction of existing crossings, which are not a part of this decision. |

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| 12.3 - Conduct actions so that stream pattern, geometry, and habitats maintain or improve long-term stream health. | a. Add or remove rocks, wood, or other material in streams or lakes only if such action maintains or improves stream and lake health.<br>b. Do not relocate natural stream channels if avoidable. Return flow to natural channels. Where reconstruction of stream channels is necessary, construct channels and floodways with natural stream pattern and geometry, stable beds and banks and provide habitat complexity. | No design criteria are applicable. | No materials will be added to channels or lake and no stream channel will be relocated. |
| 12.4 - Maintain long-term ground cover, soil structure, water budgets, and flow patterns of wetlands to sustain their ecological function. | a. Keep ground vehicles out of wetlands unless protected by at least 1 foot of packed snow or 2 inches of frozen soil. Do not disrupt water supply or drainage patterns into wetlands.<br>b. Keep roads and trails out of wetlands.<br>c. Avoid long-term reduction in organic ground cover and organic soil layers in any wetland.<br>d. Keep buried utility and pipelines out of wetlands if possible.<br>e. Avoid any loss of rare wetlands such as fens and springs.<br>f. Do not build fire lines in or around wetlands unless needed to protect life, property, or wetlands. Use hand lines with minimum feasible soil disturbance. Use wetland features as fire lines if practicable. | d. Pipelines will be kept out of wetlands where possible.<br>f. Fire lines will not be built in or around wetlands unless needed to protect life, property or the wetland. If construction is necessary, hand line is preferred over mechanical line construction. | a. This decision addresses livestock grazing, not travel management.<br>b. No new roads or trails proposed. Existing ones in suitable locations.<br>c. No long-term reduction in organic ground cover or organic soils related to wetlands will occur under proposed action.<br>e. The loss of fens or springs is not expected to occur through livestock grazing under this decision. |
| 12.5 - Manage stream flows under appropriate authorities to minimize damage to scenic and aesthetic values, fish and wildlife habitat, and to otherwise protect the environment. | a. Cooperate with water users and other interested parties to evaluate how to operate existing water use facilities to meet resource goals.<br>b. Obtain in-stream flows under appropriate federal, state, legal, and regulatory authorities to protect stream processes, aquatic and riparian habitats and communities, and recreation and aesthetic values.<br>c. Upon issuances of special use authorizations for new or existing water use facilities, include permit conditions at the point of diversion or storage, if needed to minimize impacts to water dependent resources and values.<br>d. Obtain water rights under federal and state law to protect stream processes, aquatic and riparian habitats and communities, and recreation and aesthetic values. | No design criteria are applicable. | This decision will not affect water diversions/water rights and no new water use facilities are proposed. |
| 12.6 - Manage water-use facilities to prevent gully erosion of slopes and to prevent sediment and bank damage to streams. | a. Design all ditches, canals, and pipes with at least an 80% chance of passing high flows and remaining stable during their life.<br>b. Do not flush or deposit sediment from behind diversion structures into the stream below.<br>c. Mitigate water imports and water disposal (including reservoir releases) so that the extent of stable banks, channel pattern, profile, and dimensions maintain or improve long-term stream health in each receiving stream reach.<br>d. Maintain and operate water conveyance ditches and pipelines | No design criteria are applicable. | These design criteria address water use facilities and this decision does not affect those facilities. |

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| | to carry their design volumes of water with appropriate freeboard.<br>e. Conduct snow management, including snowmaking and snow-farming, in such a manner that prevents slope failures and gully erosion on hillslopes and prevents adverse impacts, such as bank erosion and excessive sediment, in receiving streams. | | |
| **13 - Sediment Control** | | | |
| 13.1 - Limit roads and other disturbed sites to the minimum feasible number width, and total length consistent with the purpose of specific operations, local topography, and climate. | a. Construct roads on ridge tops, stable upper slopes, or wide valley terraces. Stabilize soils onsite. End-haul soil if full-bench construction is used. Avoid slopes steeper than 70%.<br>b. Avoid soil-disturbing actions during periods of heavy rain or wet soils. Apply travel restrictions if necessary.<br>c. Install cross drains to disperse runoff into filter strips and minimize connected disturbed areas. Make cuts, fills, and road surfaces strongly resistant to erosion between each stream crossing and at least the nearest cross drain. Construct roads with outslope and rolling grades instead of ditches and culverts.<br>e. Retain stabilizing vegetation on unstable soils. Avoid new roads or heavy equipment use on unstable or highly erodible soils.<br>f. Use existing roads unless other options will produce less long-term sediment. Reconstruct for long-term soil and drainage stability.<br>g. Avoid ground skidding on sustained slopes steeper than 40% and on moderate to severely burned sustained slopes greater than 30%.<br>h. Designate, construct, and maintain recreational travelways for proper drainage and armor their stream crossings to control sediment.<br>i. During and following operations and outsloped roads, retain drainage and remove berms on the outside edge except those intentionally constructed for protection of road grade fills.<br>j. Locate and construct log landings in such a way to minimize the amount of excavation needed and to reduce the potential for soil erosion. | b. Spikemoss treatment will not occur during periods of heavy rain or wet soils.<br><br>No other design criteria are applicable. | These design criteria apply to roads, trails, skid trails, landings, OHV routes, and associated features. No new travel routes are being proposed. |
| 13.2 - Construct roads and other disturbed sites to minimize sediment discharge into streams, lakes, and wetlands. | a. Design all roads, trails, and other soil disturbances to the minimum standard for their use and to “roll” with the terrain as feasible.<br>b. Use filter strips and sediment traps if needed, to keep all sand sized sediment on the land and disconnect disturbed soil from streams, lakes, and wetlands.<br>c. Key sediment traps into the ground. Clean them out when 50% full.<br>d. Keep heavy equipment out of filter strips except to do restoration work or build armored stream or lake approaches.<br>e. Build fire lines outside filter strips unless tied into a stream, lake, or wetland as a firebreak with minimal disturbed soil. | e. Where possible, fire lines will be built outside of filter strips (“a strip of land next to streams, lakes, and wetlands whose ground cover traps sediment coming from upslope”).<br><br>The other design criteria are not applicable. | This design criterion applies to road construction. |

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| | f. Design road ditches and cross drains to limit flow to ditch capacity and prevent ditch erosion and failure. | | |
| 13.3 - Stabilize and maintain roads and other disturbed sites during and after construction to control erosion. | a. Do not encroach fills or introduce soil into streams, swales, lakes, or wetlands.<br>b. Properly compact fills and keep woody debris out of them. Revegetate cuts and fills upon final shaping to restore ground cover.<br>c. Do not disturb ditches during maintenance unless needed to restore drainage capacity or repair damage. Do not undercut the cut slope.<br>d. Space cross drains according to road grade and soil type.<br>e. Empty cross drains onto stable slopes that disperse runoff into filter strips. On soils that may gully, armor outlets to disperse runoff. Tighten cross drain spacing so gullies are not created.<br>f. Armor rolling dips as needed to prevent rutting damage to the function of the rolling dips. Ensure that road maintenance provides stable surfaces and drainage.<br>g. Where berms must be used, construct and maintain them to protect the road surface, drainage features, and slope integrity while also providing for user safety.<br>h. Build fire lines with rolling grades and minimum downhill convergence. Outslope or backblade, permanently drain, and revegetate fire lines immediately after the burn.<br>i. Use the minimum amount of sand, salt, and/or other de-icing substances as necessary to provide safe winter travel conditions.<br>j. During winter operations, maintain roads as needed to keep the road surface drained during thaws and break-ups. Do not use riparian areas, wetlands, or streams for snow storage or disposal.<br>k. On roads with high/heavy traffic use, require maintenance agreements and/or use of road surface stabilization practices and dust abatement supplements. | a. Soil disturbance during spikemoss treatments will not introduce soil into streams, swales, lakes, or wetlands.<br>h. Fire lines will follow this criterion.<br><br>No other design criteria are applicable. | This decision addresses livestock grazing not travel management. |
| 13.4 - Reclaim roads and other disturbed sites when use ends, as needed, to prevent resource damage. | a. Site prepare, drain, decompact, revegetate, and close temporary and intermittent use roads and other disturbed sites within one year after use ends. Stockpile topsoil to be used in site restoration.<br>b. Remove all temporary stream crossings (including all fill material in the active channel), restore the channel geometry, and revegetate the channel banks native plants.<br>c. Restore cuts and fills to the original slope contours and as opportunities arise to re-establish subsurface pathways. Obtain stormwater (402) discharge permits as required.<br>d. Establish ground cover on disturbed sites to prevent accelerated on-site soil loss and sediment delivery to streams. Restore ground cover using native plants. | d. Sites disturbed by spikemoss treatment would be reseeded with a native seed mix, if revegetation does not occur naturally.<br><br>No other design criteria are applicable. | This decision addresses livestock grazing not travel management. |
| **14 - Soil Quality** | | | |
| 14.1 - Manage land treatments to | a. Restrict roads, landings, skid trails, concentrated-use sites, and | a. Soil disturbances will occur both on suitable and | d. This decision does not |

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| limit the sum of severely burned soil and detrimentally compacted, eroded, and displaced soil to no more than 15% of any activity area. | similar soil disturbances to designated sites.<br>b. Operate heavy equipment for land treatments only when soil moisture is below the plastic limit, or protected by at least 1 foot of packed snow or 2 inches of frozen soil.<br>c. Conduct prescribed fires to minimize the residence time on the soil while meeting the burn objectives.<br>d. Allow dispersed winter motorized recreation when snow depths are sufficient to protect soils. Specify a minimum unpacked snow depth of 12 inches unless a site-specific analysis shows a different snow depth is adequate to protect soils. Allow use of snowcats or grooming machines when unpacked snow depths equal or exceed 18 inches. | unsuitable grazing areas. Soil disturbance will be highest at concentrated use areas such as watering areas, along trails between suitable grazing areas and at collection areas (corrals, fence gates, salting). Meeting grazing strategies and standards will help to reduce soil disturbances. The activity area is considered the project area boundary.<br>b. Heavy equipment for spikemoss treatment will only occur on dry soils, when soil moisture is below the plastic limit ("the water content at which soil begins to break apart and crumble when rolled by hand into threads 3mm in diameter (Sowers 1979))".<br>c. Prescribed fire is a secondary treatment under this project and in the event that the activity occurs, precautions will be taken to minimize negative soil impacts. Precautions would include burning in the spring or fall to reduce the potential for large scale detrimental wildfire. | address recreation. |
| 14.2 - Maintain or improve long-term levels of organic matter and nutrients on all lands. | a. On soils with surface soil (A-horizon) thinner than 1 inch, topsoil organic matter less than 2%, or effective rooting depth less than 15 inches, retain 80 - 90% of the fine (less than 3 inches in diameter) post treatment logging slash in the stand after each clearcut and seed-tree harvest. Consider need for retention of coarse woody debris slash in each activity area to balance soil quality requirements and fuel loading concerns.<br>b. If machine piling of slash is done, conduct piling to leave topsoil in place and to avoid displacing soil into piles or windrows. | No design criteria are applicable. | These design criteria are more applicable to timber sales. |
| **15 - Water Purity** | | | |
| 15.1 - Place new sources of chemical and pathogenic pollutants where such pollutants will not reach surface or ground water. | a. Locate pack and riding stock sites (for example corrals and loading areas), sanitary sites, and well drill-pads outside the water influence zone (WIZ).<br>b. Locate vehicle service and fuel areas, chemical storage and use areas, and waste dumps and areas on gentle upland sites. Dispose of chemicals and containers in State-certified disposal areas.<br>c. Locate temporary labor, spike, logging and fire camps such that surface and subsurface water resources are protected. Consideration should be given to disposal of all waste. | No design criteria are applicable. | a. No new sources of pollutants exist.<br>b. No vehicle service and chemical storage areas exist within project area.<br>c. No new temporary camps are authorized under this NEPA decision. |
| 15.2 - Apply runoff controls to disconnect new pollutant sources from surface and ground water. | a. Install contour berms and trenches around vehicle service and refueling areas, chemical storage and use areas, and waste dumps to fully contain spills. Use liners as needed to prevent seepage to ground water. Prepare Spill Prevention Control and Countermeasure Plan per the requirements of 40 CFR 112.<br>b. Reclaim each mine waste dump when its use ends. Stabilize waste dumps and tailings in non-use periods to prevent wind and water erosion. If non-use will exceed one year, perform | No design criteria are applicable. | No such operations exist within project area, or are authorized in this decision and There should be no chemical spills associated with livestock grazing. |

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| | concurrent reclamation. Require removal or encapsulation of waste material as necessary to prevent contamination of nearby water bodies before operator abandons site or reclamation is accepted as final.<br>c. Prevent contaminated runoff from waste dumps and/or tailings from reaching surface and/or ground water. Potential techniques include use of lined ponds to catch runoff, diversion ditches or other runoff controls to divert runoff around waste dumps/tailings piles, capping or treating waste piles on site or off-site disposal of waste as appropriate. If ponds are used, build tailings dams with a 95% chance of containing floods (100-year event) over their design life. Permanently stabilize dams at final shaping.<br>d. Clean wastewater from concrete batching and aggregate operations before returning the water to streams, lakes, or wetlands.<br>e. Inspect equipment used for transportation, storage or application of chemicals daily during use period for leaks. If leaks or spills occur, report them and install emergency traps to contain them and clean them up.<br>f. Report spills and take appropriate clean-up action in accordance with applicable state and federal laws, rules and regulations. Contaminated soil and other material shall be removed from NFS lands and disposed of in a manner according to state and federal laws, rules and regulations. | | |
| 15.3 - Apply chemicals using methods that minimize risk of entry to surface and ground water. | a. Favor pesticides with half-lives of 3 months or less to achieve treatment objectives. Apply at lowest effective rates as large droplets or pellets. Use only aquatic-labeled chemicals in the WIZ.<br>b. Use non-toxic, non-hazardous drilling fluids when practicable. | a. If pesticides are used as part of livestock management, they will be used of the intended purposes and applied according to label directions. | b. No mining or drilling activities are part of this NEPA decision. |

**To meet the intent of the WCPH the following activities will be included in the Proposed Action:**

1. Meet established riparian grazing standards (stubble height).
2. Any restoration of organic ground cover will use certified weed-free local plants as practicable.
3. Manage livestock use through control time/timing, intensity, and duration/frequency of use in riparian areas and wetlands to maintain or improve long-term stream health.
4. Firelines will not be built in or around wetlands unless needed to protect life, property or the wetland. If construction is necessary, handline is preferred over mechanical line construction.
5. Pesticides will be used for intended purposes and applied according to label direction.
6. Spikemoss treatment will not occur during periods of heavy rain or wet soils.
7. Soil disturbance during spikemoss treatments will not introduce soil into streams, swales, lakes, or wetlands.
8. Sites disturbed by spikemoss treatment would be reseeded with a native seed mix, if revegetation does not occur naturally.
9. Heavy equipment for spikemoss treatment will only occur on dry soils, when soil moisture is below the plastic limit.